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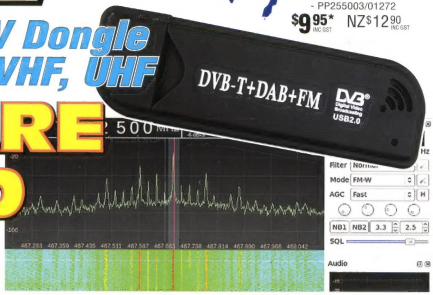

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Ref: SC Feb 2009

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Publisher's Letter

Do microcontroller projects have too many features?

One of the advantages of products with microprocessors is that it is often very easy for the designer to incorporate additional features with little or no increase in circuit complexity. And so it has been with SILICON CHIP projects. Invariably there is a temptation on the part of the designer to add this or that feature to make it more attractive to the end user. However, as the hard-nosed Publisher of the magazine, I often wish that they simply wouldn't do it. First, it adds options and choices and that, to me, is "bad". Every choice and option means that there is the chance that it will confuse the project builder and that means we get emails from readers seeking clarification.

Second, adding options means more programming time involved in developing the product. And invariably that means that more bugs have to be found and fixed. Moreover, more operating features inevitably mean that we have to take up more space to describe them in the magazine. You can see where I am coming from. In theory, we subscribe to the KISS principle (Keep it Simple, Stupid); in practice, we often don't.

And so it has been with our new DAC project which we have featured over four issues, this issue being the last. This is a classic microprocessor-controlled project; lots of features in a relatively simple circuit. It is all in the programming, you see. In fact, it wasn't until Nicholas Vinen had finished writing this last article that some of the more abstruse features were revealed. So when I was reading the article, one side of me was saying "This is more complicated than it needs to be and Nicholas has really got the bit in his teeth this time" while the other side was saying "That's really clever etc". I won't tell which side was dominant . . .

So the DAC project is not just a DAC. For a start, it is a playback device in its own right and it will decode WAV files, with various sampling rates, stored on an SD card. It also incorporates a headphone amplifier with its own front-panel volume control. Both of these were included in the long list of features in the first article. Somewhat less obvious in that same list of features was digital tone control and headphone cross-feed. Not mentioned at all, was digital volume control via the infrared remote control and to top it off, loudness compensation to the ISO specification.

Now digital volume control with the infrared remote I regard as highly desirable, if only for its convenience. I also regard it as the best method from a sound quality point-of-view, even though some audiophiles regard digital volume control as undesirable because it involves reducing "bit depth" in the audio data stream.

But loudness compensation is somewhat more debatable. On the one hand, it is a worthwhile feature because it does compensate for loss of hearing sensitivity at the frequency extremes when overall playback sound levels are reduced. On the other hand, if you choose to enable the loudness compensation, it is always going to be a rough approximation, because you don't know the level at which the program was originally recorded and how that equates with the maximum signal level that can be reproduced in your listening situation. It is a "bit of fudge" in other words, although undoubtedly far superior to the loudness control often featured in hifi amplifiers of yesteryear.

At least, the user has the choice of whether or not to use any or all of the digital control features of our new DAC. Certainly a great deal of design and programming has gone into this project but I tend to feel that we may have included too many options which many people will simply never use (and it has taken a lot of time to program all this stuff . . . Grrr).

What do you think? Should we incorporate lots of features in our microprocessor-controlled projects or should we keep them simple?

Leo Simpson

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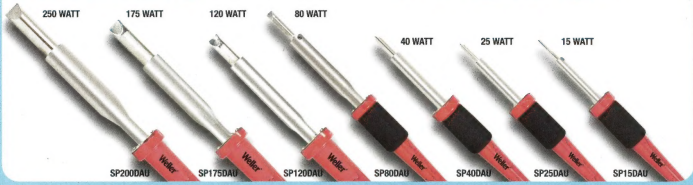

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Do wind farms really make people sick?

In the Publisher's Letter of March 2013, Leo Simpson claims that "it is recognised that wind farms can make people sick and should not be located close to where people live". I know of no survey based evidence of this in refereed scientific or medical journals that involves either laboratory animals or humans. I would be obliged if he would state his references for his assertion. Opinion and hearsay are cheap; measured evidence is not.

Mr Simpson also has a shot at "green" energy in general, particularly derived from wind. One of the world's most science/engineering literate societies, namely Germany, made a move to renewable sources of energy in the 1970s. This was inspired by US president Jimmy Carter putting solar panels on the roof of the White House, the first government building in the world to have them.

Are the Germans fools? The German government closed eight of its 17 nuclear power plants in 2011 and following the Fukushima disaster, Chancellor Merkel announced that all nuclear plants would be closed by 2022. The doom-sayers predicted blackouts and price hikes that did not occur. Greenhouse emissions have gone down and Germany remains a net exporter of energy.

Mr Simpson in earlier writings implies that he gives zero credence to human-derived rising CO_2 levels being responsible for changing climate. Surely in this day and age in which educated people are aware of the scientific method whereby science speaks in terms of probability, he may see fit to review this given that the now obvious violence and uncertainty of the weather directly threatens the food supplies of a grossly overpopulated world and immense damage to the planet.

Peter Carter,
Berwick, Vic.

Comment: it is not normal practice to quote references to back up statements in newspaper editorials and nor is it in SILICON CHIP magazine. Even if references were quoted, some people would want to challenge them. It is only recently that wind turbines have been acknowledged to produce substantial infrasonic energy and now various state governments have acknowledged that there is a problem with effects on health. Almost inevitably, there are differing points of view, as indicated by another letter in these pages.

On your point of climate change, it is not at all clear that there is any direct relationship between rapidly rising CO_2 in the atmosphere and increases in global temperature. At the very least there appears to have been a significant pause in global temperature rise, which has even been acknowledged by Rajenda Pachauri, chairman of the IPCC.

Infrasound detection & health effects

I enjoyed the Infrasound Detector article in the March 2013 issue and may make up the project.

I have had a long professional interest in the health effects of ultrasound and infrasound and vibration on the human body, as well as the measurement of infrasound, though I have never had the capability to measure infrasound properly. It is certainly an issue with ducted air-conditioning, large flares and I suspect, wind turbines. There is significant literature on the use of infrasound in various aspects of warfare, from detection of events to its use as a weapon.

I recall an article in *Scientific American* perhaps 15 or more years ago, on measuring low-frequency sound using a array of tubes like a giant octopus joined at a pressure sensor to give

Disagreement about safety of nuclear power

With reference to Alex Danilov's "Nuclear Option Is Unsafe" (page 4, April 2013 edition of SILICON CHIP), my uncle who is a retired nuclear physicist who worked for the UK Atomic Energy Commission is of the opinion that most accidents which occurred at nuclear sites were caused by what is known in the trade as "finger trouble" and "meltdown" is actually a safety feature. A serious overheating causes the fuel in the core to melt down into a catch-pot where its new geometry prevents it going critical again".

He goes on to say that no-one died at Three Mile Island. The containment vessel did its job as it was meant to and the amount of containment which escaped was quite trivial. But Chernobyl was a terrible accident killing all of those exposed to the fire-fighting and rescue work immediately afterwards. It was an early-designed reactor with a positive temperature coefficient, where deviations in temperature are controlled by moving the neutron-absorbing control rods.

He believed that "the overzealous use of moving the control rods in a positive coefficient reactor caused it to overheat and explode". They should have simply waited until the Xenon (a fission product) had died away through its radioactivity and then resumed normal operation.

Fukushima was totally attributable to being built in a known earthquake region and not sufficiently safeguarded for such an eventuality.

May I add that Sydney's Lucas Heights reactor has functioned without any problems in Australia for decades. There is a far greater hazard from the emissions caused by motor vehicles on our roads.

John Harding,
Bellerive, Tas.

very sensitive low-frequency measurements of events like earthquakes and nuclear tests. There is also an *Amateur Scientist* article in the May 1998 issue of *Scientific American* (pages 76-77) on "Sensing Subtle Tsunamis". It uses a simple micro-manometer and gives the circuit. This project cost about $50.

Associate Prof. David Bromwich, Moorooka, Qld.

Infrasound & reported symptoms

The banner used for the Infrasound Detector project on the front cover of the March 2013 issue of SILICON CHIP was "Are wind turbines making you sick?" This was repeated in the headlines for the project and further credibility for a real link between wind-farm infrasound exposure and causally related harm featured in the body of the article quoting a Publisher's Letter by Leo Simpson in the February 2010 issue.

I was dismayed that in a magazine based on science and technology with readers capable of interpreting and interested in real evidence that there was not more balance in this aspect of the article. The use of this fear factor to give the project a sense of purpose was misplaced and unscientifically based.

By way of one science-based example, an Auckland University team lead by Professor Keith Petrie has just published a paper in the Journal of the American Psychological Association showing a significant link between reported symptoms and the expectation of adverse outcomes from exposure to infrasound. Courtesy of the professor the paper itself can be found at the following link: **http://tinyurl.com/c87do3k**

This elegant research using proper randomising and double blinding showed that there is a significant impact on reported symptoms linked to an expectation of adverse outcomes. These symptoms occurred even with sham exposure to infrasound in a

Watching TV on your PC

I thoroughly enjoyed the article about watching TV on your PC in the April 2013 issue and I'm looking forward to seeing how to use my dongle as a software defined radio (SDR).

I have a Kaiser Baas KBA 01017 Radio/TV Stick which allows me to watch DTV and listen to both DAB+ and FM radio in one stick. It comes with Totalmedia 3.5 and KB Radio as Totalmedia didn't originally support DAB+ and didn't tune the FM section of the stick correctly. KB Radio provides both DAB+ and FM. As a bonus I have the beta version which also provides the slide-show images as well as Radiotext.

The Radio/TV Stick is similar in appearance to the KBA 010003 TV Stick in the article. However, the KBA 0101 has square shaping around the PAL socket rather than the round moulding of the KBA 010003.

The KBA 0101 comes with a flat bar on a suction cup antenna which is OK in the city but provides no signals here in Bacchus Marsh. An outdoor antenna is a must. Thanks for a great article.

Wenlock Burton, VK3YWB, Bacchus Marsh, Vic.

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Mailbag: continued

Circuits should have component numbers & values

In reference to comments from Peter Kay in February 2013, that you should fully label diagrams with component numbers and values, I agree with him totally.

While you produce an excellent magazine, you are being let down by prehistoric practices. Schematics should be annotated with designator and value in order to follow circuit descriptions and especially for troubleshooting.

I would like to go even further to say why are you still producing through-hole designs? 90% of circuits could be SMD and one third of the size. SMD has been around for more than 20 years; it's time to get with the technology. I do agree some exotic stuff like DFN and BGA packages would be beyond most and these can usually be avoided.

Also, after having made some recent projects, I've seen that your latest PCBs are plated through-hole and very nicely made. I don't ever want to see another single-sided PCB with 30 or 40 links on it; it's awful.

Sal Sidoti,
Lilyfield, NSW.

group that had been deliberately presensitised by seeing material claiming harm from infrasound exposure. Those who had not seen this material showed no such effects.

While it does not mean that wind turbines cannot produce adverse effects, it does provide a very plausible explanation that psychological expectations could explain the link between wind turbine exposure and health complaints.

As engineers and technicians, I'd expected better of you. The article did not need to be unbalanced and as exploitive of speculation as it was. It stood on its merits without using that technique to generate interest.

The effect of this aspect of your article is most likely to unjustifiably exacerbate anxiety and the expectation of harm in the community at large. This when evidence shows any impacts from infrasound in this context are very likely to have a psychological explanation with reporting of symptoms from those who now "know" that their headache or whatever was "caused" by the infrasound they can prove it correlates with.

Ted Linney,
Wellington, NZ.

Infrasound detector a potentially powerful tool

Your March 2013 article on an infrasound detector is highly topical at the moment and has given any person who is interested in the effects of infrasound from wind turbines a potentially powerful tool. I have already suggested the possibility of using the instrument to a wind farm opposition organisation for long-term field pattern surveys which, with professional equipment, would otherwise be extremely expensive.

In December 2011, you also produced an article for a speaker calibration meter. I am currently about to build both instruments which are so elegantly simple and inexpensive. The circuits for both instruments are essentially the same and I was thinking of combining both in the same box with switching between the two functions.

However, the gains of the Pre-Champs are significantly different and the electret microphones different. Both have C-weighted curves for which only the Speaker Meter has a correction table. It seems to me that if a C-weighted correction table was made available for the AM4011 electret in the infrasound meter, little modification would be needed to make it serve two purposes.

A more elegant solution would be to use the Champion preamp with a G-weighting filter on one input channel and a C-weighting filter on the other input channel, then use the old Champ power amplifier for lower power consumption in the field. A small add-on 12V-to-9V DC converter power supply

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Mailbag: continued

Windows Media Center gives best TV on a PC

I haven't owned a TV for years. I've watched it on PCs instead. Why would you own a TV when a PC lets you do so many things easily?

So I have more than a little experience of computer TV tuners and software. The best advice you could have given someone wanting to do it is to forget those no-name eBay TV tuner dongles with dodgy drivers and proprietary TV software and just go to a retailer like MSY and buy something like the Avermedia USB tuner. It's only about $25.

You plug it in and it immediately installs BDA drivers off the internet. Then you run Windows Media Center, controlled with the PC's mouse. The Windows Media Center in Windows 7 is the slickest TV software available. If you're not running Windows 7 you should be. If the PC you're trying to watch TV on can't run Windows 7 you're trying to teach a pig to dance.

Thank you also for pointing out to letter writer Alex Danilov on the subject of nuclear power, (Mailbag, page 4, April 2013) that the Fukushima nuclear disaster didn't kill anyone. However, you went too far in even accepting that it caused "considerable environmental damage". The exaggerated anti-science-based fear of the tiny amounts of contamination that occurred, and what was done because of that fear, is doing far more harm than the contamination.

Most of the people still evacuated from their homes don't need to be; that harmed their lives and health far more than staying where they were, or at least coming back after a couple of weeks, would have. Food didn't need to be quarantined and destroyed with that minuscule amount of contamination. And a significant number of people died because the rest of Japan's reactors were turned off, leaving the country without enough power to run air-conditioning for the old and sick.

One outcome of the Hiroshima and Nagasaki bombs was real scientific research that said that below a certain exposure, no health effect could be detected. Fukushima only exposed something like 20 people to above that level, all of them plant workers.

As someone correctly pointed out, taking a jet flight out of Tokyo would have exposed a person to more radiation than staying there.

Gordon Drennan,
Burton, SA.

could also be used which would open up the possibility of running off 12V DC from a car, a 230VAC plugpack or a larger 12V battery pack such as those used in power tools; a small project in itself which could have multiple uses.

It seems to me these designs of elegant simplicity and low cost (hiding the extensive development effort) have uses which are far beyond those applications first envisaged. Coupled to a modest computer and the internet, a very powerful measurement system can be created at very low cost unit cost and within the technical capabilities of a significant percentage of the population.

This also seems to be a superb project for high school students.

Kelvin Jones,
Kingston, Tas.

Mains voltage can be up to 260VAC

I want to comment on the High & Low Mains Voltage Alarm on page 43 of the March 2013 issue. The text seems to blame grid-connected solar power systems for the high voltages. It is probably correct but there is more to it than that.

I had not really taken much interest in my local mains voltage until I had a 5kW solar system installed last year. I subsequently found that the mains voltage at the house was going over 255VAC on quite a few occasions and up to 260VAC at times. I estimated that my own system when fully operational was contributing nearly 3V to this voltage. What it actually adds to the grid, I don't know but it would be less than that.

The local energy supplier (Ergon) technical representative came out to investigate. Fortunately, the voltage was above the limits when the system was inspected and subsequently reported. Some of his comments are summarised as follows.

Their aim is to keep the mains voltage around the 240VAC mark with a lower limit of 228VAC and an upper limit of 253VAC. The mains voltage is continuously monitored and transformer taps are adjusted accordingly at the local substation. However, the monitoring point is not ideal and the readings depend on industrial area loadings which are obviously high during the day and much less at night and during the weekends and holidays. A high load would mean a higher voltage to compensate but it may mean that other customers on a different branch may get a higher voltage than anticipated.

He also mentioned that they do occasionally have problems with their monitoring and switching gear and as a result, the mains voltage can remain unnecessarily high. The taps on the local transformers are also set up to try to keep the local voltages within the prescribed limits throughout the day. It is a big balancing act which doesn't always work out.

Adding grid-connected solar power does compound the problem. As most of us know, the power grid is designed to deliver power, not have it generated at the supposed load end.

In the event, I recently received a letter from Ergon saying that the voltage regulation problems I was having have now been fixed and if I have any further problems, I should contact my solar system installer.

There is also the issue of the solar system shutting down if the voltage does get too high. In Queensland, this is supposed to be set at 255VAC but many installers leave the settings at the default value which appears to be over 260VAC. Mine has yet to turn off due to high voltage. This really annoys my neighbour as his is set correctly and is often turning off, while others around him are not. My installer has been advised and is supposed to come out and adjust it.

Brian Playne,
Toowoomba, Qld.

Autotransformer won't save power

I refer to the letter on page 9 in your March 2013 issue entitled "A power saving device that really does work" and hope that the author fully understands what he is doing. I believe that there are flaws in the claims and do not believe that it works.

Firstly, our power authorities have a responsibility to deliver power to consumers within defined parameters, one of which is voltage, and thus there are tolerances on allowable voltage fluctuations. In Victoria, for 3-phase, this is 415VAC +6%, -10% (or 400VAC +10%, -6%) for steady-state conditions. Equipment builders design their devices to operate within these tolerances. If the tolerances are exceeded, the equipment may fail or function incorrectly and also any warranty would be void.

If you have a supply at 255VAC during the day it is still within tolerance. However, at night when the grid-connect solar systems cease to support the grid, the voltage will most probably return to its nominal 240VAC. Allowing for the 25VAC reduction via the autotransformer, the feed then falls to 215VAC which is just outside the allowable tolerance.

If the grid voltage comes down to its permissible minimum steady state value, the output voltage from the autotransformer will fall to around 194V, which is well outside of tolerance and may give rise to equipment misbehaviour or damage.

Secondly, with motors, one needs to understand the characteristics of motors and the loads they drive. Some loads require the same torque to move them no matter at what speed they are driven at, whilst for others the torque changes with the driven speed. An example of this is a centrifugal pump or a fan where the torque required falls away according to the square of the speed. The load torque has just as much bearing on the current that the motor will draw as does the voltage applied to it.

Without going too heavily into theory, a motor is a device which delivers torque at a given speed. For an induction motor, the speed is governed predominantly by the grid frequency which is fixed at 50Hz. Through the action of slip, if the supply voltage to the motor is reduced, it will increase its current draw in order to maintain its output speed. A shunt-connected universal (AC commutator) motor will behave similarly under the action of back-EMF. Result: voltage goes down, current goes up and there is no nett power saving; just the possibility of thermally damaging the motor.

A series-connected universal motor will slow down if the torque requirement is maintained and the supply voltage decreased. The result then is that the input power will reduce but so will the output from the motor (output power is torque x speed) and it will take longer to do the given task. As we pay for electrical energy in kWh, using less kW for more hours still means no nett energy saving.

Thirdly, as for incandescent lamps, there will undoubtedly be a reduction in power if the supply voltage is reduced and they will last longer but remember there will be a corresponding reduction in light output. You will save power but will compromise on illumination. A simple light dimmer will do the same thing.

There are legitimate means to minimise energy consumption through sound engineering principles but simply reducing supply voltage is not one of them. Generally, very few of these low-cost quick fixes actually work. The most effective energy saving method is to purchase quality, efficient devices and moreover, decide carefully when you really need to run them.

As a very last point I do hope that

Wrong thermostat switch specified

Regarding your answer to the "Ask SILICON CHIP" topic on 'Temperature Switch For Fan Control', page 96, March 2013, your suggestion to use a Jaycar ST-3821 (60°C Thermal Circuit Breaker/Switch) would appear to achieve the reverse of A. R.'s intention to turn fans ON when 60° is reached.

Christo Curtis,
Beaconsfield, NSW.

Comment: you are correct. We should have specified the normally open (NO) thermostat switch Jaycar ST-3831.

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Mailbag: continued

Print images for best longevity

In response to Paul Kirk's letter in the March 2013 issue about long term data storage, I also have similar concerns.

Photographic images printed on paper can last a very long time, of the order of many decades or centuries. They also don't require any hardware or software to view and can even be useful if they are suffer from physical damage such as a tear.

Apart from the uncertain longevity of various storage media such as DVDs, digital data suffers the problem of requiring constant migration to new media and data formats as well as the software and operating systems that support them as the older ones become obsolete. Over the longer term it is difficult to see that all custodians of such data will continue to do this into the future.

Fortunately, the problem is now recognised by many archival organisations such as national libraries although it is likely that huge amounts of data will continue to be lost by other organisations or individuals not so committed to data preservation. Also, anything uploaded onto the internet is likely to stay around for a very long time.

My personal preference with photographs is to print them so there will always be a paper copy (if not destroyed by accident) and I also include in the album a DVD of the photos which hopefully I will periodically migrate to new media as appropriate.

I refer interested readers to the article on digital obsolescence at **http://en.wikipedia.org/wiki/Digital_obsolescence**

Dr David Maddison,
Toorak, Vic.

the common connection on the autotransformer was made in the neutral.

Neil Smith,
Parkdale, Vic.

NBN connections may pose a problem

I wish to draw attention to what may become a problem for many with the connection of their premises to the NBN. The nature of this problem is illustrated in the NBN Co site **http://www.nbnco.com.au/blog/gallery-nbn-fibre-installation.html**

The premises shown in this site appears to be having a new installation of a communication service. However, what will happen in the vast majority of cases is that the NBNCo "Premises Connection Device" (PCD) will be connected at, or very close to, wherever the existing telephone service is attached to the premises – be that via underground conduit or via an aerial connection.

Using the wording of NBN Co, the story is as follows: After "the (external) Premises Connection Device is affixed to the wall" the "fibre optic cable is coiled up inside the

Premises Connection Device, and connected to a 'fibre patch lead' which runs through to the inside of the house."

"The installer then requests permission to enter the house, and discusses where the internal equipment should be installed."

"The installer carefully measures where the equipment should be installed and cross references that with the position of the Premises Connection Device on the outside of the house."

"He drills a small hole in the wall to pull the cable through" and "The fibre-optic cable comes through to the interior of the house."

While this all sounds very nice when set out as above, what it really means is that, unless the householder makes other arrangements, the NBNCo installer will place the (external) Premises Connection Device close to the existing telephone entry point, drill through the wall close to that point and mount at least two or, possibly, three boxes on the inside wall of your lounge room, bedroom, office etc. Note that the back-up battery and Power Supply Unit (PSU) has now become "optional".

If the householder wants to place the equipment out of sight elsewhere he/she will need to make it easy for the NBNCo installer to "pull" the fibre optic cable through a suitable duct from the external "Premises Connection Device" to the preferred location for the internal Fibre Wall Outlet (FWO).

The requirements for this are set out in **www.nbnco.com.au/assets/documents/preparation-and-installation-guide-for-sdus-and-mdus.pdf** (3.4.2 Conduits and Structural Integrity). The current version of this document now refers to "White 25mm (nominal OD), 23mm (nominal ID), PVC-U telecommunications conduit, labelled with the word: 'Communications'."

Previous versions of this document specified ducting with exactly the same dimensions as Telstra "20mm" conduit (which actually has an outside diameter of 26.7mm), although the NBNCo referred to it as "25mm" conduit.

There appears to be no stipulation as to the maximum length of the ducting. Note that the "25mm" Communications conduit and fittings available from a new large hardware store chain are NOT interchangeable with the (Telstra) "20mm" conduit and fittings available from electrical suppliers and the other large hardware store chain.

The latter document is mainly a guide for new buildings under construction. However, in conversations with knowledgeable staff at the NBN Co Melbourne Discovery Centre in Docklands (which is being relocated to Sydney) they indicated that NBN Co would be happy to take advantage of any assistance arranged by the householder in providing ducting and access for the fibre optic cable to a dry, clean, accessible, well-ventilated site with a dedicated General Purpose Outlet (Power Point). It is then up to the householder to arrange cabling from the Network Termination Device (NTD) to his/her computer, router/WiFi, switch, phone etc but he/she would have to do that if the equipment were to be simply stuck on the lounge room wall!

Peter B Taylor,
Box Hill North, Vic. SC

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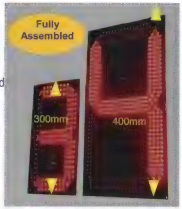

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Back in June 2012, we reviewed the WiNRADIO Excalibur software-defined radio (SDR), an impressive communications radio in a tiny diecast metal box which connects to a PC. Now you can get an SDR covering a frequency range from around 50MHz (or lower) up to 2200MHz for just the price of a USB DVB-T dongle – peanuts!

LAST MONTH, we showed you how to use a cheap USB DVB-T dongle to watch TV or listen to digital radio on your PC. But they can do even more interesting stuff. Using the right software, one of these can turn your PC into a wideband VHF/UHF multi-mode SDR – a software-defined radio receiver. And yes, it also has its own spectrum display.

Don't get us wrong – a USB DVB-T dongle cum software-defined radio is not going to give you the same great performance as a WiNRADIO Excalibur. However, it is going to give you a very wideband receiver with many of the facilities of a fully-fledged communications receiver. So let's look at the background.

Back in the late 1970s, firms in the USA and Germany began developing fully digital radio transmitters and receivers for use by the military and space industries. At first, these were classified but gradually the results of this work started to percolate through into commercial "software-defined" radio receivers and transmitters, in which many of the functions previously performed by dedicated hardware modules were performed by complex software or firmware.

The advantages were obvious: lower cost, lower weight and much greater functional flexibility.

It soon became clear that software-defined radio or "SDR" was likely to become just another kind of PC application. This process received a dramatic boost in 2009 when Antti Palosaari, a Linux software developer in Finland, made an interesting discovery when

Table 1: Common DVB-T Dongle Tuner Chips & Their Frequency Ranges

Tuner Chip	Frequency Range	DVB-T dongle model in which chip is found
Elonics E4000	52 – 2200MHz*	EzCAP EzTV668 DVB-T/FM/DAB, many current 'no name' devices
Rafael Micro R820T	24 – 1766MHz	? (not known – but may be in many future dongles)
Fitipower FC0013	22 – 1100MHz	EzCAP EzTV645 DVB-T/FM/DAB, Kaiser Baas KBA010008 TV Stick
Fitipower FC0012	22 – 948MHz	Many of the earlier DVB-T dongles

*With a gap from 1100MHz to 1250MHz (approx) NOTE: Elonics may have ceased manufacture

he was working on Linux drivers and routines to allow DTV reception using one of the DVB-T dongles which had just started to appear. Delving into the firmware code inside the Realtek RTL2831U demodulator chip that was used in most of the early dongles, he found that it had an undocumented "radio" mode, presumably intended to allow FM reception as well as DTV reception. In this mode, the chip would output a stream of 8-bit I/Q (in-phase/quadrature) digital samples via the USB port, at rates of up to 2MS/s (megasamples per second).

Antti Palosaari realised that this would allow other kinds of demodulation to be performed by software in the PC. This was confirmed when almost all later DVB-T dongles came with the higher-performance Realtek RTL2832U demodulator chip with the same in-built "radio" mode as its predecessor.

So Palosaari got together with other software developers from Osmocom (the Open Source Mobile Communications group) and they soon developed suitable drivers and software for both Linux and Windows.

Now anyone can have a wideband VHF/UHF SDR, using a low cost DVB-T dongle and a PC or laptop. So let's take a look at what a typical SDR/USB dongle set-up can do.

Same hardware as before

Just as with DTV and DAB+ reception, the only hardware you'll need for using your PC as an SDR is the PC itself (with a free USB 2.0 port), a low-cost DVB-T dongle and a decent outdoor VHF/UHF antenna. Everything else is handled by software.

Which type of DVB-T dongle is best suited for use in an SDR? That depends on what range of frequencies you want to receive, because the main difference between most of the currently available dongles is their tuner chip, as mentioned last month. And the main difference between these tuner chips is their tuning range – see Table 1.

So if you're mainly interested in scanning frequencies up to 1100MHz or so, almost any of the dongles will likely do the job. But if you want to tune much higher frequencies, you're going to need a dongle with either the Elonics E4000 or the Rafael R820T tuner chip inside – like the EzTV668 or many of the current "no name" dongles.

Fig.1: an omnidirectional antenna like this Icom VHF/UHF discone is ideal for use with an SDR.

Note that although the Elonics E4000 tuner chip covers the widest frequency range, it also has a gap between about 1100MHz and 1250MHz where it has no coverage. So if you are particularly interested in receiving signals in this region, you'll want to search the online market for a dongle with the Rafael R820T tuner chip inside. We're not aware of any just yet but they're probably around on the web if you look hard enough.

Remember too that dongles with the E4000 tuner chip in them may not be available for much longer, as Elonics has apparently gone out of business. So when the dongle makers use up their stocks of the E4000, many of them will have to swap over to the R820T anyway.

How about the antenna? Well, as we noted last month, the tiny "whip" antenna that comes with many DVB-T dongles is pretty useless even for DTV and DAB+ reception – and it's even more useless for SDR reception. So you're really going to need a decent outdoor VHF/UHF antenna.

For your initial SDR experiments, you'll probably get moderately encouraging results by using a standard TV antenna. However, as these are generally quite directional, they'll tend to be very insensitive to signals coming from directions other than directly in front. In practice, you'll get much better results from an omnidirectional VHF/UHF antenna like a "ground plane" or (preferably) a "discone".

A discone is a wideband omnidirectional antenna with two main elements: a horizontal disc on the top and a conical shape below it (rather like an inverted ice-cream cone). Both the disc and cone elements may be made from either sheet metal or an array of stout wire "spokes". Sheet metal elements are more common in discones intended for use at frequencies above 1GHz, while "spoke" elements are generally used for discones intended for use at lower frequencies.

By the way, the discone antenna was invented and patented by US engineer Armig G. Kandoian in the mid 1940s.

Some discones intended for use down into the lower VHF region have an additional vertical whip element at the top, to effectively convert the antenna into a half-wave vertical dipole at the lower frequencies. This is the case with the discone shown in Fig.1, which is a wideband VHF/UHF antenna made by Icom about 15

The SDR# Application & Its Features

SDR# is an easy to use software application designed to turn almost any PC into a powerful SDR (software defined radio), using either a DVB-T dongle (the hardware "front end") or other devices. Here are some of its salient features:

(1) RF performance, frequency accuracy: the RF performance basically depends on the chips used in the DVB-T dongle used with SDR#. A typical dongle fitted with the Elonics E4000 tuner chip can tune from 52-1100MHz and 1250-2200MHz, with a sensitivity of approximately 1.5µV for 12dB of quieting at frequencies up to about 180MHz, rising to about 20µV for the same degree of quieting at 990MHz.

The SDR# software used with the dongle provides a Frequency Correction feature, whereby you can correct for any frequency error in the DVB-T dongle. In addition, there is a Frequency Shift feature, allowing you to display the correct frequencies even when you have an up-converter connected ahead of the dongle.

(2) Demodulation modes: AM (amplitude modulation), NFM (narrow frequency modulation), WFM (wide frequency modulation), LSB (lower sideband), USB (upper sideband), DSB (double sideband), CW-L (carrier wave with BFO on low side) and CW-U (carrier wave with BFO on high side).

In all these modes, the RF filter bandwidth can be adjusted over a wide range, while the filter type can be selected from a range of five (Hamming, Blackman, Blackman-Harris, Hann-Poisson or Youssef). The filter order can also be selected over a wide range. In both CW modes, the frequency separation of the software BFO can also be adjusted. There is adjustable squelch and also both linear and "hang" AGC.

(3) FFT spectrum display and/or Waterfall spectrum/time display: the FFT spectrum display and Waterfall display can be selected either separately or together. The windowing function used can be selected from six choices: None, Hamming, Blackman, Blackman-Harris, Hamm-Poisson or Youssef, and the display resolution can be adjusted over a wide range by changing the block size from 512 to 4,194,304, in powers of two, with the higher resolutions requiring greater processing overhead.

Good results can be achieved with the default resolution of 4096, which was used for all of the screen grabs shown in this article.

years ago. It originally sold for about $100 but Icom don't seem to sell them anymore.

However, Australian firm ZCG Scalar make what they call a "Basestation Omnidirectional Broadband Discone". Designated the B51H, this is available through their dealer network – see their website at **www.zcg.com.au**

If you search around on eBay, you'll find that suitable VHF/UHF discones are also available for online purchase. In particular, we found one from Mr CB Radio of Richmond, Victoria for $97.00 plus postage. Another one called the "Jetstream JTD1" was available from a couple of US suppliers (CQ Radio Supply and k1cra Radio Store) for between US$33 and US$56, with a further $50 or so for postage to Australia.

There's also information available on the web showing how to make your own discone, eg, see **helix.air.net.au** Another website at **www.ve3sqb.com** has software that works out the element dimensions for various antennas (including discone antennas).

Software is crucial

As with DTV and DAB+ reception, the software needed to configure a PC/dongle combination as an SDR consists of two main components: (1) a driver which allows the PC to communicate via the USB port with the Realtek RTL2832U (or similar) demodulator chip inside the dongle and (2) the application software to allow the PC to perform all the functions of an SDR in company with the dongle hardware.

The driver must be installed first. The most popular driver for a DVB-T dongle with an RTL2832U demodulator chip (when used as an SDR) is the "RTLSDR" driver (nearly all dongles use the RTL2832U). There's even a website at **rtlsdr.org** which provides lots of information about it.

Zadig

The easiest way to install the RTL-SDR driver is to use an open-source driver installer program called "Zadig". Developed a couple of years ago by Pierre Batard, Zadig is currently available as version 2.0.1.160 in two forms, one for Windows XP and the other for Windows 7.

Both are about 5.2MB in size and they can be downloaded (as self-installing exe files) from **sourceforge.net/projects/libwdi/files/zadig**

It's important to get the right one for the version of Windows on the PC you'll be using for the SDR. Note that both files are compressed in a "7z" archive format, so you won't be able to extract the exe file from the download with WinZip. Instead, they can only be extracted using 7-Zip, a compression/extraction utility which offers a higher compression ratio. Fortunately, this too can be downloaded, either from **sourceforge.net** or directly from the 7-Zip developer's website at **www.7-zip.org**

7-Zip also comes in two forms – one for 32-bit x86 systems (ie, Windows XP) and the other for 64-bit x64 systems (eg, PCs running 64-bit versions of Windows 7).

If you don't already have 7-Zip, the first step is to download and install it. Then you can download the correct (and latest) version of Zadig, after which you can use 7-Zip to extract the *Zadig.exe* installer file. You then run this file to install Zadig itself.

With Windows 7, you have to run the installer file as the Administrator. This is very important, as otherwise it won't install Zadig correctly.

Next, plug your DVB-T dongle into the USB 2.0 port you intend to use for the SDR. Windows will then go through its usual rigmarole, looking for what it thinks is a suitable driver for the dongle. Don't worry if it does this though, because you'll be using Zadig to install the correct SDR driver shortly.

Now start up Zadig in the usual way. With Windows XP, you should immediately see the dialog shown in Fig.2. With Windows 7, you'll almost certainly get a User Account Control window first. Click "Yes" to allow Windows 7 to run Zadig, to display the same start-up window.

Next, click on the Options menu and you should see a drop-down menu as shown in Fig.3. Click in the blank area just to the left of "List All Devices" and the drop-down Options menu should

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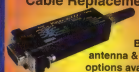

Fig.2: the Zadig startup window. This application is used to install the RTL-SDR driver to allow the PC to communicate with the Realtek RTL2832U demodulator.

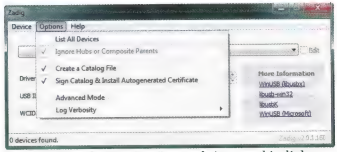

Fig.3: clicking the "Options" menu brings up this dialog after which you have to select the "List All Devices" option from the drop-down list.

Fig.4: clicking the down arrow brings up the list of USB devices that Zadig has discovered. You then have to select the USB dongle entry from this list.

Fig.5: the RTL2838UHIDIR entry has been selected here (for an EzTV668 dongle). You then have to click the "Reinstall Driver" button to install the correct driver.

disappear. However, there will now be some text displayed in the main drop-down menu bar, probably for one of your USB devices like a mouse, keyboard or printer.

Click on the down arrow at the right-hand end of this bar. You should get a drop-down list of all of the USB devices that Zadig has been able to find connected to your PC – see Fig.4.

You now have to go through this list to find the DVB-T dongle that's plugged into one of the USB ports. The only catch here is that it can be listed under various different names, depending on the dongle.

Some dongles may appear as "RTL2838UHIDIR" as shown at the bottom of the list in Fig.4, while others may be shown as "Bulk-In, Interface (Interface 0)" as shown in Fig.6. Still others may appear as "RTL2832U" or similar. The main things to look for are either that "Bulk-In, Interface" label or one starting with "RTL".

When you spot the dongle in Zadig's list, click on its entry to highlight it. Zadig should now display the dongle's label in the main horizontal bar, as shown in Fig.5 and Fig.6. However, at this stage it either won't be showing anything in the Driver text box or it'll be showing whatever driver Windows installed (or tried to install) when you plugged the dongle into a USB port.

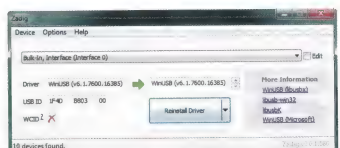

Fig.6: this screen grab is similar to Fig.5 but in this case, after Zadig has installed the correct RTL-SDR driver for Kaiser Baas KBA010008RT dongle.

Either way, you'll probably see text entries in the smaller boxes to the right of the "USB ID" label, as shown in Figs.5 & 6.

Now turn your attention to the blue rectangular button at the lower centre of the Zadig window, which will probably be displaying the text "Reinstall Driver". If it isn't, click on the down arrow at its right-hand end and select Reinstall Driver from the resulting drop-down list. Once the correct text is displayed, click on this button to install the correct driver for SDR.

After "whirring" away for a few seconds, Zadig should display a "Successful Install" message and then you should see the correct driver name displayed in both the Driver text box and also in the box further to the right (just to the right of the green arrow). You can see the driver displayed in these boxes in Figs.5 & 6.

The driver should now be installed correctly and will be called up automatically whenever your dongle is plugged into the same USB port at a later time. So if you always plug the dongle into the same port when using it for SDR, you won't have to fire up Zadig to reinstall the driver again.

Conversely, if you plug the dongle into another USB port, you'll have to run Zadig again to reinstall the driver for that port. As a corollary to this, you will be able to use the same dongle for DVB-T and DAB+ reception simply by plugging it into a different USB port; ie, one for which Zadig hasn't installed a driver.

What's next?

Once Zadig has installed the SDR driver, exit the application in the usual manner. However, before you move on to download and install the SDR application software, it's a good idea to go into Control Panel -> System and

Security -> Device Manager to make sure that the driver has been installed correctly.

In Device Manager, scroll down to "Universal Serial Bus Devices" (see Fig.8) and click on the arrow to the left. You should now see a device entry with the same name as that previously shown in Zadig (it's shown as "RTL2838UHIDIR" in Fig.8). This will be your dongle and if you then right-click on this device name and select "Properties", you should see another small window like that shown on the right in Fig.8.

Click on the Driver tab in this window and you should be presented with the details of the driver that Zadig installed. As shown in Fig.8 the Driver Provider should be shown as "libusbx.org" and the Driver Version as "6.1.7600.16385" (or another number if it has been updated from the current version).

If that all checks out, then Zadig has correctly installed the SDR driver for your dongle and you're now ready to install the application software.

Our first choice: SDR#

If you search the web, you'll find a number of different SDR software applications that run under Windows or Linux and are compatible with RTLSDR dongles. The most popular of these seems to be an application called SDR# or "SDRSharp", written by a programmer in Paris by the name of Youssef Touil in collaboration with various other people around the world.

SDR# is a particularly powerful and easy to use SDR application and it's available for free. It provides an excellent way to "dip your toe" into SDR.

Downloading and installing SDR# is a little tricky though, because it's not packaged as a "single exe" or "zipped exe" file. Due to licensing and packaging considerations, it has been split into two main zip files which can be downloaded from the SDR# website – plus another zip file which must be downloaded from a different website.

Here's the downloading procedures, step by step:

STEP 1: fire up your web browser and go to the SDR# homepage at **www.SDRSharp.com** Then click on the "Downloads" heading to go to the downloads page. Here you'll find two main files. One will have a name like *SDR# Dev* or *sdr-nightly*, followed by a description in brackets like (Continuous Integration, Last Changes Rev: 1114). This is the main SDR# zip file, so download it first. That done, move down to the file named *SDR# RTLSDR Plugin*, which will have a similar description in brackets. This will be the latest version of the RTLSDR "plugin" for SDR# and this is the second zip file to download.

STEP 2: before leaving the SDR# website, scroll further down the downloads page until you get to a section titled "Important note for RTL-SDR users". This section provides links to various worthwhile items on SDR#, including a PDF file of a well written "SDR# User Manual" by Henry Forte. You can download this PDF file by clicking on the link **www.atouk.com/wordpress/?p=153**

STEP 3: the next step is to download the third main software ingredient. This is "rtlsdr.dll", the application extension which SDR# needs to communicate with the RTL-based dongle via the USB driver. This file can't easily be downloaded by itself but it's in a collection of other files which can be downloaded from the Osmocom website at **http://sdr.osmocom.org/trac/wiki/rtl-sdr/**

To do this, scroll down to a section at the end called "Attachments". In the links beneath this heading, you'll find one with the rather odd name "RelWithDebInfo.zip". Click on this link and you'll end up on a page headed "rtl-sdr: RelWithDebInfo.zip". This file can now be retrieved by clicking on the "downloading" link over on the right.

Installing the software

Having downloaded the three zip files, you can now proceed with the software installation for SDR#. Here's how it's done:

STEP 1: unzip the *SDR# Dev.zip* (or sdr-nightly.zip) file. This will have about 14 files inside, all of which should be extracted to the folder you will be installing SDR# in. For example, you could extract the files to *C:\Program Files\SDR#*, so it's a good idea to create this folder before you start.

Step 2: unzip the second zip file, ie, with a name like *sdr-nightly-rtlsdr.zip*. This will probably have five files inside, plus a folder called "config". Extract everything to the same folder used to store the extracted the files from the first zip file. That done, check the contents of the "config" folder

Coming: An Up-Converter For HF Reception

As shown in Table 1, none of the tuner chips used in currently available dongles will tune down below 22MHz, while dongles with the popular E4000 tuner chip won't go below 52MHz. So by themselves, none of these dongles are suitable for turning your PC into an SDR covering the LF/MF/HF bands (these bands include broadcast-band AM radio and various shortwave radio and amateur radio bands).

So, we're working on a small "up-converter" to connect ahead of the DVB-T dongle. This up-converter covers the frequency range from about 0-60MHz and shifts the tuned LF/MF/HF signal by 125MHz up into the VHF spectrum, well within the dongle's tuning range.

We plan to describe the up-converter in SILICON CHIP in the near future.

Fig.7: DVB-T tuner dongles can be purchased online quite cheaply. These three units all feature a 75-ohm Belling-Lee antenna socket but many other dongles come with a much smaller MCX connector.

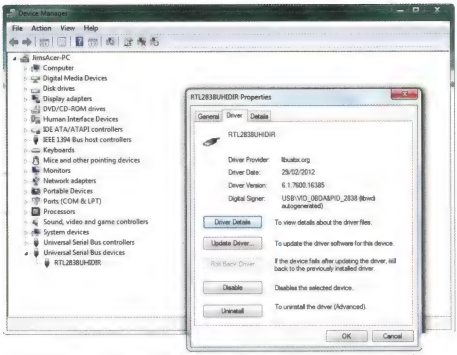

Fig.8: you can verify that Zadig has correctly installed the driver by checking the entry in the Windows Device Manager.

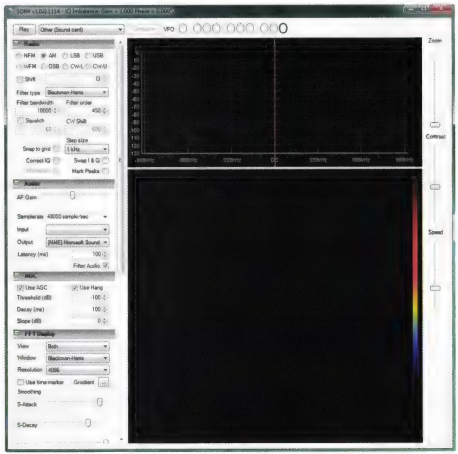

Fig.9: this is the opening window that appears when you start the SDR# program for the first time.

there should only be one file with a name like *sdrsharp.exe.config*. Copy this file into the main SDR# folder, where it will over-write an existing file with the same name.

Step 3: now for the third zip file you downloaded, ie, *RelWithDebInfo.zip*. Inside this file, you'll find two folders, one labelled "/x32" and the other "/x64". If you look inside the /x32 folder, you'll see a file called *rtlsdr.dll*. This is the only file you need from this third zip file, so just extract this file and place it into the main SDR# folder with the others.

And that's it. Your copy of SDR# should now be fully installed and ready to run. All you need to do is go to the *C:\Program Files\SDR#* folder (or wherever you have installed it), right click on the filename *SDRSharp.exe*, and select either "Run" in Windows XP or "Run as Administrator" in Windows 7.

SDR# in action

After a couple of seconds SDR# should spring into life and you'll see a fairly large window like that shown in Fig.9. This is the opening window for the current version of SDR#, V.1.0.0.114; later versions may look a little different.

At the top left of this window are two rectangular buttons, one labelled "Play" and the other with the default label "Other (Sound card)". Clicking the down arrow to the right of this label will now bring up a drop-down device list similar to that shown in Fig.10. Click the "RTL-SDR/USB" option then click the "Configure" button.

SDR# will now open a very interesting supplementary window as shown in Fig.11. This shows you the actual name of the dongle (in this case "ezcap USB 2.0 DVB-T/DAB/FM dongle"), the tuner chip it contains (here an E4000), its maximum and default sample rate (2.048MS/s) and the default sampling mode (quadrature sampling). It also gives you options for setting the AGC functions available inside the dongle (RTL AGC and/or Tuner AGC) and for adjusting the RF gain.

In addition, there are options for setting a tuning offset (for when you're using an up-converter with the dongle) and for correcting for any frequency error in the dongle's crystal-based local oscillator. We'll discuss these options later on.

For the present, just click on the "Close" button at the bottom of this window, then take a close look at the main SDR# window. Down the left-hand side, you'll see the SDR# control panel. This is divided into a number of functional areas, each with its own

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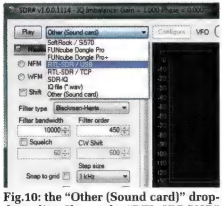

Fig.10: the "Other (Sound card)" drop-down list. Choose the "RTL-SDR/USB" option, then click "Configure".

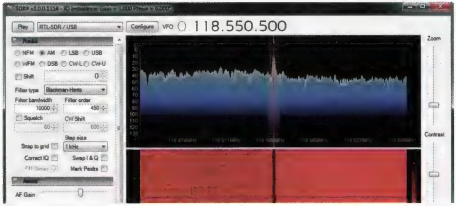

Fig.12: SDR# showing a typical spectrum display. In this case, the unit has been tuned to an AM signal on 118.550500MHz in the aeronautical band (the Sydney Airport Terminal Information signal).

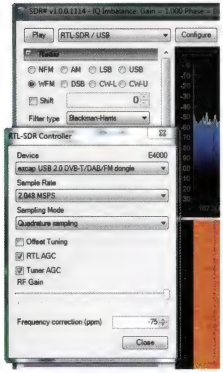

Fig.11: the RTL-SDR Controller dialog. It shows the name of the dongle, the tuner chip (here an E4000), its maximum and default sample rate (2.048MS/s) and the default sampling mode (quadrature sampling). There are also options for AGC and RF gain.

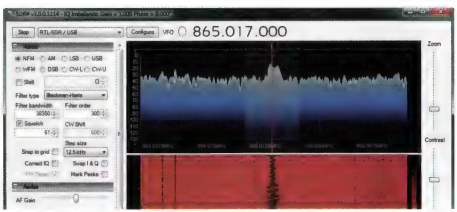

Fig.13: the result when SDR# was tuned to 865.017MHz in the UHF fixed/mobile communications band. The signal peak is a narrow-band FM (NFM) signal coming from a tourist guide on the Sydney Harbour Bridge.

heading, ie, Radio, Audio, AGC, FFT Display and finally two area headings at the bottom for SDR# plugins.

Within each area you'll find various control buttons allowing you to select a variety of functions and modes. For example, the eight small buttons at the top of the Radio section allow you to select the demodulation mode you want to use (NFM, AM, LSB, USB, WFM, DSB, CW-L or CW-U). Most of the other controls are fairly intuitive, like the AF Gain slider at the top of the Audio section. You simply drag this slider one way or the other to decrease or increase the volume.

Tuning a frequency

In the centre at the top of the main SDR# window, you'll see the label "VFO" followed by a string of 10 large numerals. At this stage, these will probably all be zeroes and with all but the rightmost digit "greyed out". This is SDR#'s main tuning frequency display and it's also where you can directly enter the frequency you want to receive.

Entering the frequency you want is easy: just move the mouse cursor over either the top half or the bottom half of any of the digits, which will cause a square of colour shading to appear behind that half of the digit (blue for the bottom half, or pink for the top half). Then if you left click on that coloured square, the digit will either increment or decrement to change the tuning frequency.

It reads directly in Hertz, so to tune your SDR to say 136.9125MHz you need to set the display to (0.)136.912.500.

Frequency/spectrum display

Just below the main frequency display is SDR#'s frequency/spectrum display window, which is probably its most impressive feature. This gives a continuous display of the spectrum in the vicinity of the tuning frequency you've set, with signal amplitude plotted vertically against frequency which is along the horizontal axis. This makes it particularly easy to spot the peaks or "bumps" which correspond to any signals in that part of the spectrum.

If the frequency you want is actually away from the current tuning frequency, you can simply drag the tuning cursor (the vertical red line in the centre) over to the signal peak and drop it there.

By the way, if there are a lot of signals visible, all jumbled together in the spectrum display, you can zoom in to a smaller section of the spectrum display simply by dragging up the "Zoom" slider on the right of this

window. There are other handy features too, which we'll look at shortly.

For the present though, let's look briefly at one big feature of SDR# that we haven't yet mentioned: its "waterfall plot" display window. This is just below the spectrum display window at lower right. Although this window is almost totally black in Fig.9 apart from a "rainbow strip" at far right, when SDR# is receiving it displays a time plot of the visible signals in the spectrum display window.

This lets you see which ones are varying with modulation or are appearing in short bursts (ie, with gaps in the signal). You can adjust the colour contrast within this window using the "Contrast" slider at centre right and you can vary the time period represented by the waterfall plot using the "Speed" slider below it.

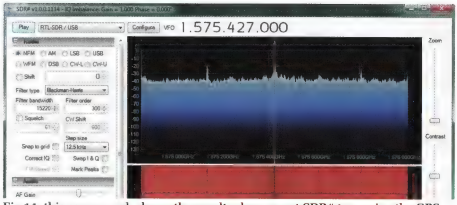

Fig.14: this screen grab shows the result when we set SDR# to receive the GPS "L1" signal frequency at 1.575427GHz. There was indeed a small signal peak at that frequency but we were unable to demodulate the signal because SDR# doesn't have an option to demodulate CDMA spread spectrum signals.

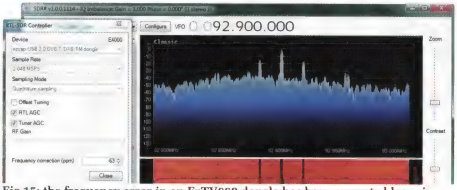

Fig.15: the frequency error in an EzTV668 dongle has been corrected here, in this case using the signal from ABC Classic FM in Sydney, on 92.900MHz. The frequency correction applied was -63ppm (parts per million).

Receiving a signal

OK, let's use it to receive a signal. There are really only three steps involved:

(1) enter the frequency of the signal you want to receive by clicking on the appropriate digits in the top display;

(2) select the modulation mode (eg, AM, WFM, LSB etc) by clicking the corresponding radio button in the Radio section at top left; and

(3) click on the "Play" button just above the Radio heading, at top left.

Within a fraction of a second, you should see a spectrum display like the one shown in Fig.12. In this case, the unit has been tuned to an AM signal on 118.550500MHz in the aeronautical band (it's actually the Sydney Airport Terminal Information signal). The display has been zoomed in a little and is showing the spectrum between about 118MHz and 118.66MHz, with the peak for the signal being received in the centre (bisected by the red tuning cursor line).

Looking closely at Fig.12, you'll also see a light grey band straddling the signal peak and the tuning cursor. This shows another of SDR#'s handy features – it can graphically display the software filter bandwidth currently in use.

If you change the filter bandwidth using the text box over in the Radio controls area, you'll see the grey band change width. But that's not all; you can also change the filter bandwidth by hovering the mouse over one side of the grey band until the cursor changes into a double-ended horizontal arrow. When it does, you can then click and drag the edge of the band one way or the other, to change the filter bandwidth.

What if you do find a signal peak but the audio output is badly garbled (even when you tune accurately to the centre of the peak)? This indicates that it's not using the type of modulation you've

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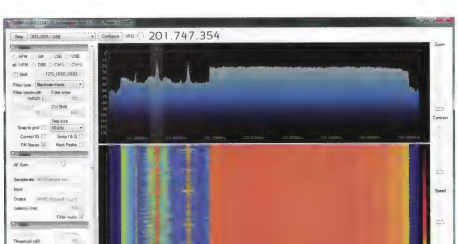

Fig.16: the spectrum and waterfall displays on SDR# for the Channel 9 sound carriers in Sydney. It shows the primary and secondary FM sound carriers for analog Ch9, plus the DAB+ "block" of multiplexed digital audio signals in Ch9A.

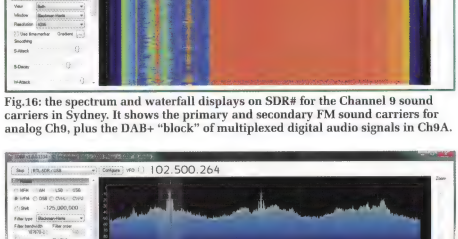

Fig.17: the spectrum and waterfall displays for three FM stations between about 102.5MHz and 104.1MHz.

set SDR# to receive. That's fixed by clicking on the other mode buttons in the Radio area until the signal becomes clear. When that happens, you have the correct receiving mode.

As mentioned before, you can change the tuning frequency by clicking and dragging the red tuning cursor line in the spectrum display window. When you do this, you'll see the main frequency display at the top changing as you drag the cursor. In addition, the frequency "dial markings" along the bottom of the spectrum display will also slide along.

If you want to shift the tuning frequency a long way from your current setting, it's much easier to click on the digits in the main frequency display at the top. If you like, you can think of this display as the SDR's "band switching" control, while dragging the cursor in the spectrum display window is its "fine tuning" control.

Two more screen grabs which should make the impressive capabilities of SDR# a little clearer are shown in Figs.13 & 14. Fig.13 shows the SDR# tuned to 865.017MHz in the UHF fixed/mobile communications band. The signal peak turned out to be a narrow-band FM (NFM) signal coming from a tourist guide up on the Sydney Harbour Bridge (he was explaining the history of the bridge and its surroundings)!

Fig.14 shows the result when we set the SDR# to receive the GPS "L1" signal frequency at 1.575427GHz. There was indeed a small signal peak at that frequency but its small size is not surprising since we were only using the wideband discone antenna shown in Fig.1. In any case, we were unable to demodulate this signal because SDR# doesn't have an option to demodulate CDMA spread-spectrum signals. Instead, all we could hear was a faint hum when the "AM" demodulation mode was selected.

SDR# is also unable to demodulate DAB+ digital (COFDM) signals (perhaps this will be added in a future update). However, if you do want to listen to DAB+ radio, it's just a matter of plugging the dongle into a different USB port and firing up a DVB-T/DAB+ application.

Frequency error correction

At this stage, there's one aspect of the DVB-T dongle plus SDR# combination that we haven't considered: its tuning accuracy. Inside virtually all currently available DVB-T dongles is a 28.8MHz crystal oscillator. This is used as a clock generator and frequency reference by both the tuner and demodulator chips.

This means that the basic tuning accuracy of the dongle (and as a result our SDR) depends on the accuracy of this crystal oscillator. Not surprisingly, most low-cost dongles use a fairly low-cost crystal and its exact frequency can vary over quite a wide range.

To overcome this problem, Youssef Touil and his colleagues provided SDR# with an elegant way of compensating for this "dongle tuning error". This was done by building in a method

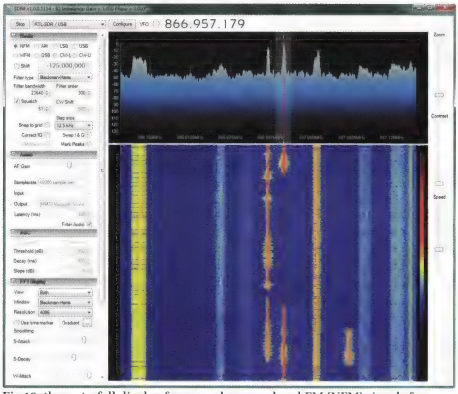

Fig.18: the waterfall display for several narrow-band FM (NFM) signals from Sydney airport (centre) plus various other digital signals.

to allow SDR# to automatically correct its frequency calculations by a known factor (which will be different for each dongle).

This may sound complicated but it's really quite easy. All you have to do is select a signal whose carrier frequency is accurately known and then set SDR# to tune to that frequency. Then when you click on the "Play" button, you should see the carrier peak for this signal somewhere near the centre of the spectrum display.

The next step is to click on the "Configure" button to call up the RTL-SDR Controller window and then turn your attention to the "Frequency correction (ppm)" text box with its up/down arrows. It's then just a matter of clicking on one arrow or the other to move the signal peak so that it's centred on the correct tuning frequency.

If that still sounds complicated, take a look at Fig.15. This screen grab was taken after using the above technique to correct the frequency error in an EzTV668 dongle, in this case using the signal from ABC Classic FM in Sydney, on 92.900MHz.

As shown, the carrier signal peak has been moved right into the centre of the spectrum display, so that it straddles the 92.900 graticule line. And, as can be seen in the RTL-SDR Controller dialog box, this was achieved by getting SDR# to apply a frequency correction of -63ppm (parts per million).

This correction process only has to be done once for each dongle, by the way. Of the other three dongles we tested, one required a frequency correction of -115ppm and another a correction of +20ppm. The remaining "no-name" dongle required no correction at all; it was spot on, probably by sheer good luck.

Give it a go

So that's a quick run through the main features of SDR# and how easily it can be used to convert your PC into an SDR and wideband VHF/UHF spectrum scanner. It's a bit of a rigmarole to download and install the special RTL-SDR driver and then SDR# itself but once you've done that, the set-up is remarkably flexible and easy to use.

The only small "glitch" we've encountered so far is that sometimes when exploring the VHF or UHF bands, there's a spurious signal peak in the centre of the spectrum display. This is probably due to signals radiated from the PC getting into the dongle. If you come across this, try enclosing the dongle in a metal shield and/or fitting the USB cable with a clip-on ferrite suppressor sleeve. SC

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Raspberry Pi

By GEOFF GRAHAM

The Raspberry Pi is an internet phenomenon. It is a small, single board computer costing just $35 and it caused a sensation when it was first released, selling more than a million units in the first 12 months. So what is the Raspberry Pi and what's all the fuss about?

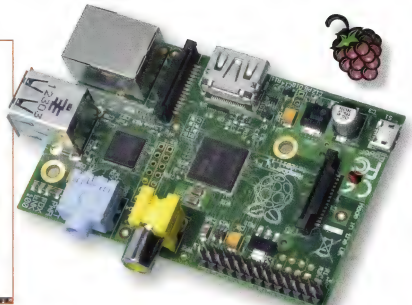
FOR ANYONE WHO has been living under a rock and has not heard of the Raspberry Pi, a short description is in order. It is a small computer on a credit card-sized PCB which packs a lot of punch. It has two USB ports, HDMI video output with up to 1920 x 1200 resolution, composite video, stereo audio, Ethernet and a number of general purpose input/output pins.

It runs Linux and it boots up into a graphical Windows-like environment where you can run a web browser, word processing and so on. It sounds like a cheap PC and it is. But there's a lot more to it than that . . .

In the beginning

The Raspberry Pi was developed by a number of aca-

This is what you can expect once you have connected everything to the Raspberry Pi and booted it up. It features a graphical user interface which looks a little like that on a Windows PC or an Apple Mac. You can browse the web, write programs and do word processing. Performance is not bad considering that the Raspberry Pi costs $35 and is the size of a credit card.



The top side of the Raspberry Pi board is quite compact, being the same size as a standard credit card. In the centre is the Broadcom BCM2835 ARM processor which runs at 700MHz. This is hidden by the Samsung memory chip which is mounted on top of the Broadcom ARM chip, a technique known as "package on package" technology (see panel).

demics in the Computer Laboratory of the University of Cambridge (UK). They were concerned about the declining skill levels of students entering the Computer Science courses.

In the 1990s, most prospective students had gained a basic knowledge of programming from playing with the hobby computers that flourished in the 1980s. But by the late 2000s, the typical incoming student might have done a little web design but not much more.

Their idea was to resurrect the heydays of the 80s and 90s by making available a cheap computer that could be used by students at home and in the classroom to learn the basics of programming. Thus the Raspberry Pi was born, with the initial aim of building just 1000 units for new undergraduates at the University of Cambridge. Overall development took six years and during this time the expectations for the device increased enormously.

From the beginning, the Raspberry Pi was surrounded by a lot of hype. Even before it was available for sale, the first 10 boards were put up for auction on eBay and sold for about 70 times their retail price. This and other events ensured that there was plenty of media and internet coverage before the official launch in February 2012.

When the Raspberry Pi was eventually released, this promotion paid off handsomely. Eager buyers rushed to enter their orders and the ensuing chaos brought the distributors' websites to their knees. When their systems recovered, the whole production run of 10,000 units sold out within hours. Just three weeks later, orders had reached 200,000 units – this despite the fact that the estimated delivery delay at that time was measured in months.

For most of the past 12 months the Raspberry Pi has been out of stock at various times and by the time that you read this, over a million will have been sold.

Designing the Raspberry Pi

When the University of Cambridge dons set out to design the Raspberry Pi, they had a couple of aims; it had to be cheap and it had to meet the technical expectations of today's tech-savvy younger generation.

Raspberry Pi Resource Sites

Official Raspberry Pi website: **www.raspberrypi.org/**

The official Raspberry Pi discussion forum: **http://www.raspberrypi.org/phpBB3**

The Raspberry Pi Store (download software, including games): **http://store.raspberrypi.com/projects**

RS Components Sales Website: **http://australia.rs-online.com/web/generalDisplay.html?id=raspberrypi**

Element 14 Sales Website: **http://www.element14.com/community/groups/raspberry-pi**

News items for the Raspberry Pi: **http://www.geek.com/articles/tagged/raspberry-pi/**

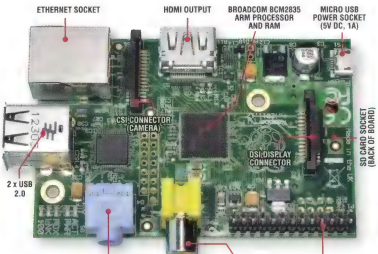
Some things that users have done with their Raspberry Pi: **http://www.treehugger.com/slideshows/gadgets/20-awesome-projects-raspberry-pi-microcomputers/**

XBMC – A very capable Media Player that runs on the Raspberry Pi: **http://xbmc.org/**

Turn your Raspberry Pi into a network storage manager: **http://www.howtogeek.com/139433**

Why "Raspberry Pi"?

It seems that the name is not particularly significant but is simply based on a "friendly fruit" and an abbreviation for Python, the recommended programming language for the device.



The layout of the connectors on the Raspberry Pi board. It's almost the same size as a credit card.

They did this by adopting mass production techniques and mobile telephone technology. For example, the main processor uses a package-on-package technique (see the panel) pioneered by the mobile phone industry, in which two chips are stacked on top of each other. Another example is the PCB where lasers are used to bore holes in the PCB for the vias (instead of a drill).

Overall, the PCB is about the size of a credit card and is covered on both sides of the board with components (many microscopic). There's definitely no assemble-yourself-kits or hand-soldering here; it's only sold in assembled form.

The main processor is a Broadcom BCM2835 which is an ARM processor running at 700MHz and designed for multimedia applications. It includes most of what is needed in a computer so it is called a system-on-a-chip (SoC). This includes a graphics processor (capable of Blu-ray quality playback), digital video output, audio system, memory controller and some general purpose I/O used for the SD card interface and other duties. Stacked on top of this is a 512MB memory chip (256MB on the cheaper Model A).

The only other significant chip on the board provides the two USB ports and an ethernet interface. Other than a few voltage regulators and a logic buffer, that's it; a complete computer based on two chips.

The resulting Raspberry Pi is well equipped. It has a HDMI interface for a monitor, two USB ports (generally one is used for the keyboard and the other for a mouse), a 10/100 Ethernet socket and 17 general-purpose I/O pins which you can use for a serial port, I^2C interface etc. An RCA composite video output socket and a 3.5mm audio jack socket are provided for people who do not want to use the HDMI digital video/audio output.

All the software for the unit is stored on an SD card.

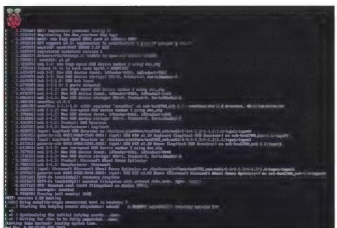
What Is Package On Package?

The Raspberry Pi uses a package on package technique to conserve board space and reduce costs. This technology was initially developed for the mobile phone market and in the Raspberry Pi's case, this means that the memory chip is stacked on top of the processor chip.

Both packages use a ball grid array (BGA) to connect the chip to the PCB but in the case of the memory chip (which is on top), the BGA connects to the carrier for the processor chip below. This makes sense as most of the memory interconnects will go to the processor chip – see **http://upload.wikimedia.org/wikipedia/commons/0/08/ASIC_%2B_Memory_PoP_Schematic.JPG**

The main advantage of package on package technology is the small size of the final assembly and the elimination of the copper tracks to connect the memory to the processor. Other useful characteristics include faster signal propagation and reduced noise and crosstalk.

The main disadvantage (for us mere mortals) is that for all practical purposes these can only be assembled and soldered by robots.



This is an example of what you will see as the Raspberry Pi boots up. The total boot time is under a minute.

The underside of the Raspberry Pi board is also covered with components, some of which are microscopic. That's why the Raspberry Pi is sold fully-assembled – only robots can practically assemble such a board.

Getting it running

The Raspberry Pi comes with only a single sheet of paper entitled "Quick Start Guide". So to get it going you will need a number of additional components.

Power for the unit is supplied via a micro USB connector (this is for power only) so you will need a plugpack/charger with one of these connectors. These are readily available as they are used by many smart phones, book

The Raspian OS is stored on an SD card which is inserted into a socket on the back of the board.

readers etc. If you already have a phone charger with a micro USB plug, you're in business.

You will also need a monitor (up to 1920 x 1200 resolution) with an HDMI input. If your monitor has a DVI socket, you can use it with an HDMI to DVI adaptor cable. Alternatively, if your monitor has a VGA socket, you will need an HDMI to VGA adapter cable. Both of these are readily available where computer accessories are sold or via the internet.

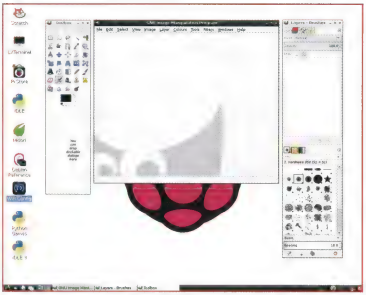
You will also need a USB keyboard and a USB mouse. Finally, an SD card (or Micro SD card with an adaptor) with a minimum capacity of 2GB (4GB or more is recommended) is needed for the operating system and applications.

To get started, you first have to download the Linux operating system from the Raspberry Pi website and install it onto your SD card (using a larger personal computer). There are a number of operating system variants to choose from but it's usually best to use the official version called "Raspbian". This version is well-supported and has a graphical interface similar to other operating systems in use today.

Once you have plugged everything in and applied power, the Raspberry Pi will chug through loading Linux until you are at the graphical user screen. The whole boot up process takes about a minute.

Now what?

The Linux/Raspbian interface is a lot like the Microsoft or Apple graphical user interface that most of us are



Raspian lets you install and run all sorts of applications on the Raspberry Pi, including the Gimp (an image editing program). Don't expect it to operate at lightning speed though.

used to. You use the mouse to point at icons, menus and windows and click to run or select. The windows on the screen can be resized and dragged around or minimised. It is amazing to consider that all this is being generated by the tiny Raspberry Pi.

You can run a web browser or a word processor and use the thing like a tiny personal computer. It is not the fastest computer on the block but considering that the whole computer is on a credit-card-sized PCB, it's not bad.

Once you move beyond the superficial, the complexities of Linux will become more obvious. For people who are familiar with Linux, this will be well-known territory but for the rest of us, it can initially be a little confusing when you try to do something like install an application or configure a network.

This is where some people who have bought the Rasp-

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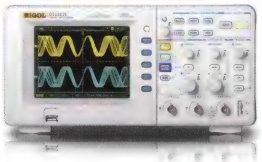

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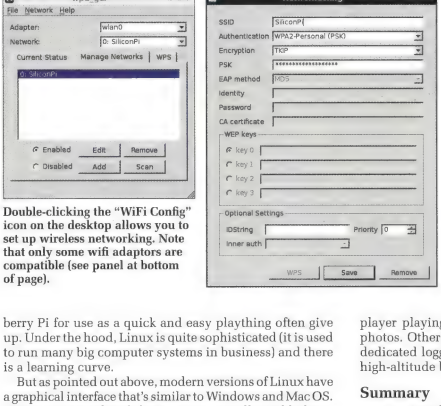


Double-clicking the "WiFi Config" icon on the desktop allows you to set up wireless networking. Note that only some wifi adaptors are compatible (see panel at bottom of page).

berry Pi for use as a quick and easy plaything often give up. Under the hood, Linux is quite sophisticated (it is used to run many big computer systems in business) and there is a learning curve.

But as pointed out above, modern versions of Linux have a graphical interface that's similar to Windows and Mac OS. Once you've explored the menus, you will quickly learn where the various application and configuration dialogs (eg, for WiFi set-up) reside. Some set-up configurations may require command line instructions and a quick search using Google will usually turn up the procedure.

Getting the Raspberry Pi going on a wired network is straightforward. We simply connected it to our router and the router's DHCP server then handed out an IP address and the gateway address. After that, we were able to browse the internet but connecting to network shares requires the installation and configuration of additional software (Samba).

If you have a compatible wifi adaptor, then you need to double click the WiFi Config icon and enter the network details to get it up and running. Note that the WiFi adaptor may need to be connected via a powered hub, as the Raspberry Pi can only supply a limited amount of power.

Programming the Raspberry Pi

If you don't want to do any programming, you could use the Raspberry Pi as a desktop computer for web browsing, spreadsheets and so on.

It is rather clunky in this role and as most people already have a desktop computer or laptop, it would not have any particular advantage. The Raspberry Pi is also hampered by its limited memory and the SD card storage – so there is a practical limit in what you can do with it.

To get the best from the device you need to learn how to write programs for it and the recommended language for this is Python. This is a sophisticated language that looks a little like Java or C and comes with a huge library of functions to control graphics, the operating system and the hardware. If you don't like Python you can install compilers for other languages such as Java and C/C++.

All these languages are quite powerful and companies such as Google and Facebook use them to build massive software systems but it is another steep learning curve for those of us who have not been brought up in the Linux/web programming world.

There are some easier to use languages such as a limited BASIC but coupled with the Linux operating system, the experience is still a long way from the simple world of the Apple II and Commodore 64 that introduced many kids (now older readers of this magazine) to the world of programming in the 80s.

However, if you are prepared to climb the learning curve you will have a potent tool. For example, because of its power, the Raspberry Pi can act as a web server, serving a whole website. The web server could even be used to serve up dynamic data received on its 17 general purpose input/outputs.

It could form the core of a multimedia player playing your MP3 collection or displaying your photos. Others have written games for it and used it for dedicated logging or controlling applications like riding high-altitude balloons and directing robots.

Summary

At a price of just $35 the Raspberry Pi is an easy impulse buy and that must be part of the reason why over a million have been sold. But in many cases, when it is booted up, the complex operating system and programming languages may convert that impulse buy into something that is put aside and forgotten. We advise people not to give up.

Learning Linux/Python can be a rewarding experience and a good career move for many. In that case, the Raspberry Pi is an excellent tool for the job.

The target audience for this little computer is the technical whiz kid who is at home in the graphics/web world and who expects to go on to university to do a Computer Science degree. If just a few percent of them get it into their hands, it will have done its job.

The Raspberry Pi comes in two versions; Model A with 256MB memory (US$25) and, the more popular Model B with Ethernet and 512MB memory (US$35). To these prices you will have to add the cost of freight ($10-20) and accessories such as the power supply, mouse, monitor and keyboard.

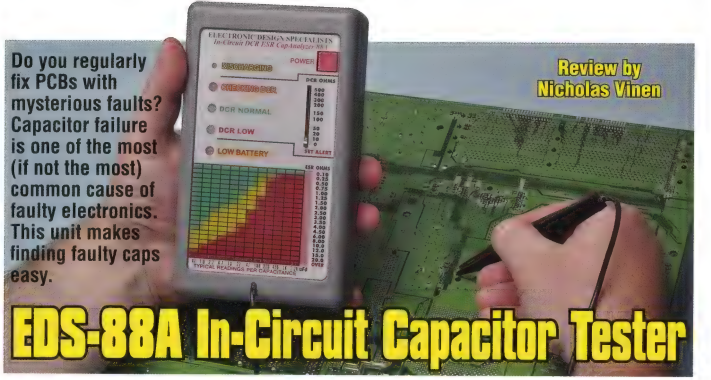
Where to buy it

Australian distributors now have stock and either model can be ordered online from **rs-online.com** or **www.element14.com** SC

Compatible WiFi Adaptors

A list of compatible WiFi adaptors can be found at **http://elinux.org/RPi_VerifiedPeripherals#Working_USB_Wi-Fi_Adapters** Note that some adaptors may require the installation of additional software to get them working and they may have to be plugged into a powered hub (see text).

For a list of other compatible devices, refer to **http://elinux.org/RPi_VerifiedPeripherals**



Do you regularly fix PCBs with mysterious faults? Capacitor failure is one of the most (if not the most) common cause of faulty electronics. This unit makes finding faulty caps easy.

EDS-88A In-Circuit Capacitor Tester

If you're trying to figure out why a board is no longer working properly, bulging electrolytic capacitors are a pretty good clue and simply replacing them (or even just replacing all electros) is often the cure.

But sometimes the fault isn't so obvious and although ceramic and plastic film capacitors are pretty reliable, they do fail. It can be really frustrating having to pull a lot of components off the board and test them individually to figure out which one has gone wrong.

That's where this in-circuit ESR and DC resistance analyser can come in very handy. Not only can you test the capacitors without having to remove them but it's really easy and quick to check each cap – vital if the board is sprinkled liberally with them, as some are. The unit measures ESR from less than 0.1Ω to 20Ω which covers just about any (working) capacitor you will come across.

Test procedure

The procedure is simple. With the CapAnalyzer 88A turned on and ready, you connect the tweezer prongs across one of the capacitors and wait a couple of seconds. The unit automatically discharges the capacitor if it is charged, possibly from testing another nearby capacitor; you don't use this unit to test circuits while they are powered. It then checks the capacitor's DC resistance (to see if it's leaky or shorted) and then, if that's OK, measures its ESR.

After about three seconds, the result of the test is displayed using LEDs; a bar graph to show the ESR or a fault LED if the DC resistance is below the limit threshold (indicating a shorted or leaky cap). However the unit also makes different tones and beeps depending on the result of the test which is great since you can keep your eyes on the PCB and just test one capacitor after another, relying on the tones to tell you if you find a bad one.

In-circuit testing

Because this unit performs the ESR test at such a high frequency, it does a pretty good job of isolating each individual capacitor (due to the parasitic inductance of the PCB traces joining them).

So that means if there are several capacitors in parallel, you have a good chance of figuring out which one is bad. It also means other nearby components shouldn't affect the accuracy of the capacitor ESR measurement.

The test voltage is low (around 50mV RMS) so active components like transistors and ICs won't interfere with the ESR reading either and with such a low test voltage, nothing in the circuit should be damaged by the test.

So you can probe around the board with confidence, testing each capacitor until you find the culprit(s).

To find a shorted or leaky cap, the unit compares the DC resistance across the probes to a value set with a slide pot to between 500Ω and (close to) 0Ω.

Higher settings increase your chance of finding a leaky cap but also increase the chance that other components in the circuit could cause a false reading, hence the ability to adjust the threshold. They recommend a setting of around 50Ω for most circuits.

Also, if all you want to do is measure ESR and you know the capacitor(s) are discharged, you can put the unit into a special mode where all it does is measure and display ESR full-time.

Is it any good?

In a word: yes.

We really only have a couple minor complaints; overall it works very well.

The provided tweezer-type probe is great for testing SMD capacitors (ceramic and tantalum). It can also be used for smaller electros but can be a bit tricky for larger electros – you have to spread it open to reach across more widely-spaced terminals.

The issue is that this probe is hard-wired into the unit. Having said that, while it isn't ideal in all circumstances, if you had to pick one type of probe to use, it's probably the best compromise to suit all the various kinds of capacitor you will want to test.

Besides that, the only other complaint we can come up with is that the unit is quite large and heavy compared to other portable test instruments.

But that can be an advantage too; it has rubber feet so with its heft won't easily slide off a desk. Plus since the test leads are quite long and you don't necessarily have to look at the unit while using it, so you can always put it to one side anyway.

The EDS-88A is powered by four AAAs which are claimed to give several hours of use. The case must be opened up to replace them so if you are using the unit constantly, you will want to get the mains adaptor kit.

This is a very handy piece of test gear for servicing electronic equipment with a cleverly thought-out user interface. Dear A to Z: can we keep it?

The CapAnalyzer 88A is available in Australia from A to Z Electronix for $350, including GST. Purchase (or get more information) from their website at www.atoz-electronix.com.au SC

The CLASSiC-D ±35V DC-DC Converter

Delivers up to ±35V & 125W from a 12V battery with high efficiency

By JOHN CLARKE

This compact DC-DC converter was designed to mate with our CLASSiC-D Amplifier (published in November & December 2012). It presents an efficient way to run the CLASSiC-D amplifier module from a battery to make it a compact powerhouse. Of course, it can also be teamed up with other SILICON CHIP amplifier modules too, if you already have them on hand, and its output voltage can be adjusted over a small range.

THIS DC-DC CONVERTER is designed to deliver ±35V DC supply rails from a 12V DC input. At that setting, it will enable the CLASSiC-D Amplifier to deliver some 100W into 4Ω and 60W into 8Ω. This is certainly less than the CLASSiC-D's maximum output of 250W when powered from ±55V supply rails but we have chosen this setting as a good compromise between power output and battery life.

And while the DC-DC Converter can be used with other power amplifier modules which have a similar supply rail requirement, they will not be as efficient as the CLASSiC-D module and therefore will not give you as much audio output for a given battery current.

The DC-DC Converter is housed in a

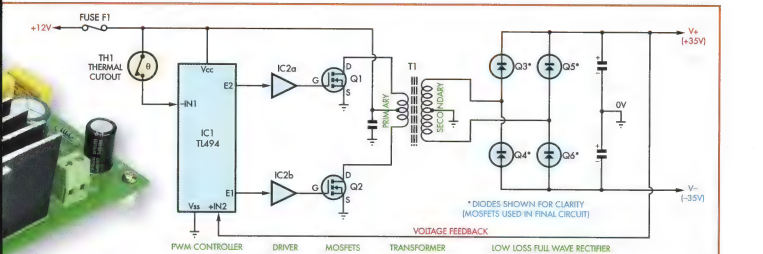


Fig.1: a simplified diagram of the DC-DC Converter. It uses a TL494 switchmode PWM controller (IC1) to drive Mosfets Q1 & Q2 in anti-phase and these drive transformer T1 at about 25kHz. The transformer secondary then drives a rectifier stage to derive ±35V rails.

rugged diecast box measuring just 119 x 94 x 57mm. Just add the CLASSiC-D Amplifier module and a 12V SLA battery and you have the basis for a powerful portable PA amplifier or a really punchy busking amplifier, with good battery life.

DC-DC converter basics

The DC-DC converter works by alternately switching 12V to each half of a centre-tapped transformer primary winding. The resulting AC waveform is then stepped up in the transformer's centre-tapped secondary, rectified and filtered to provide the plus and minus supply rails.

Fig.1 shows the basic schematic of the DC-DC Converter. It operates at a switching frequency of about 25kHz and uses a high-frequency ferrite transformer. Mosfet Q1 drives the top half of the step-up transformer, while Q2 drives the bottom half. The secondary winding's centre-tapped output is fed to a bridge rectifier and filter capacitor stages to develop the plus and minus DC output rails.

The Mosfets are driven via separate drivers, IC2a & IC2b, by a TL494 switchmode chip (IC1) which has feedback to keep the positive DC voltage to a set value (ie, 35V). This feedback controls the width of the pulses applied to the gates of the Mosfets. If the voltage rises above the set value, the width of the gate pulses is reduced and vice versa. The two Mosfets are switched in anti-phase, so that when one half of the winding is conducting, the other is off.

Fig.1 shows the rectifiers as diodes but in reality they are Mosfets, hence the Q numbers (eg, Q3, Q4 etc). The reason for using Mosfets instead of fast recovery diodes is that they are far more efficient, since they have less forward voltage drop than diodes.

The circuit also incorporates a low voltage cut-out and over-temperature protection. If the battery voltage drops below 11.5V, the converter switches itself off. This is essential if you are powering the converter from a 12V SLA battery. If these batteries are allowed to discharge much below 11.5V, they will be rendered useless. That can be expensive and frustrating!

Over-temperature protection is provided by a thermal cut-out attached to the inside the diecast case. If the case temperature exceeds 60°C, the thermal cut-out opens and the converter shuts down. When it cools sufficiently, normal operation resumes, with no harm done.

Main Features & Specifications

Features

- Compact housing
- Efficient rectifier circuitry
- Thermal shutdown
- Fuse protection
- Power indication

Specifications

Power supply: 11.5-14.4V using a 12V battery (or 24V with modifications)

Power rating: 50W continuous, 125W peak (enables the CLASSiC-D amplifier to deliver up to 100W into 4Ω on normal program material)

Standby current: 130mA at 12.6V

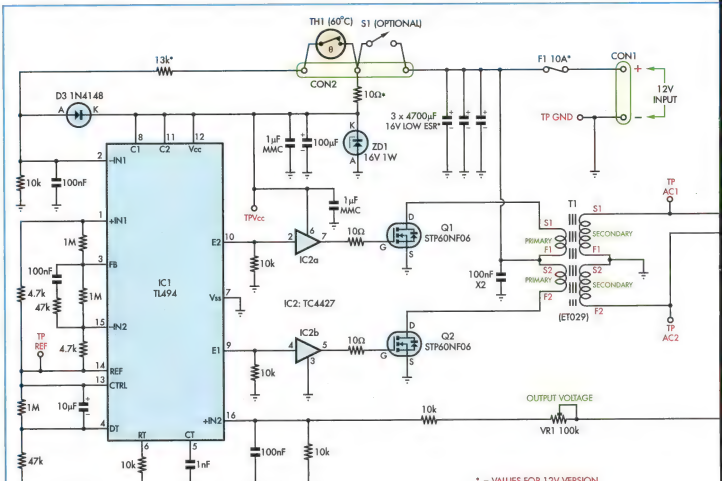
Standby Current with CLASSiC-D Amplifier connected: 220mA in protect mode; 490mA in run mode with no signal

DC supply ripple at 60W load: less than 2V

Circuit details

Fig.2 shows the full circuit of the CLASSiC-D DC-DC Converter while Fig.3 shows the internal circuitry of the TL494. It is a fixed frequency pulse width modulation (PWM) controller containing a sawtooth oscillator, two error amplifiers and a PWM comparator. It also includes a dead-time control comparator, a 5V reference and output control options for push-pull or single ended operation.

The PWM comparator generates the variable width output pulses by comparing the sawtooth oscillator waveform against the outputs of the two error amplifiers. The error amplifier with the highest output voltage sets the pulse width.



SC 2013 CLASSIC-D DC-DC CONVERTER

Fig.2: the full circuit of the CLASSiC-D DC-DC Converter. It uses Mosfets Q3-Q5 to rectify the AC from transformer T1's secondary and these are controlled by four IR11672 secondary side driver (SSD) ICs (IC3-IC6). Each SSD monitors the voltage across its Mosfet to determine when to switch the Mosfet on or off via the V_{GATE} output.

Pin 13 selects single-ended output or push-pull operation. In our design, push-pull operation is selected and the outputs appear at the transistor emitters, with the collectors tied to the positive supply.

Dead-time comparator

The dead-time comparator ensures that there is a brief delay between one output going high and the other going low. This means that the outputs at pins 9 & 10 are both low for a short time at the transition points.

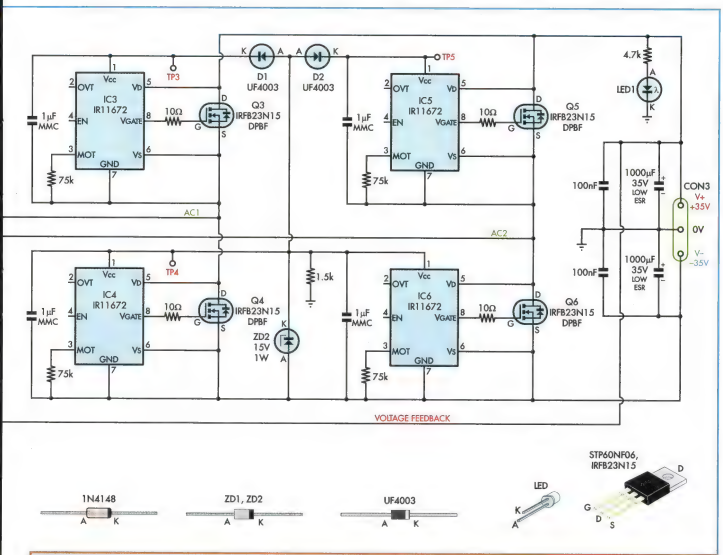
This dead-time period is essential, since without it, the Mosfet driving one half of the transformer would still be switching off while the other Mosfet would be switching on. This would destroy both Mosfets as they would effectively create a short circuit across the 12V supply.

One of the error amplifiers in IC1 is used to provide the under-voltage protection. Pin 2 monitors the +12V rail via a voltage divider consisting of 10kΩ and 13kΩ resistors. Non-inverting input pin 1 connects to IC1's internal 5V reference at pin 14 via a 4.7kΩ resistor. When the voltage at pin 2 drops below 5V (ie, when the battery voltage drops below 11.5V), the output of the error amplifier goes high and the PWM outputs at pins 9 & 10 go low, thus shutting the circuit down. The 1MΩ resistor between pins 1 & 3 provides a small amount of hysteresis so that the output of the converter does not rapidly switch on and off if the battery is close to the 11.5V threshold.

The over-temperature protection operates with a 60°C thermal cut-out (TH1) connected in series between the voltage divider on pin 2 and the positive supply rail. If the case temperature reaches 60°C, TH1 opens and so the circuit shuts down by turning the PWM off.

The second error amplifier in IC1 is used to control the output voltage of the DC-DC Converter. This amplifier has its inputs at pins 15 & 16. The feedback voltage is derived from the positive side of the bridge rectifier and is attenuated using a voltage divider consisting of VR1, a series 10kΩ resistor plus a 10kΩ resistor to ground. The resulting voltage is then fed to pin 16 of IC1 and compared to the internal 5V reference which is applied to pin 15 via a 4.7kΩ resistor.

Normally, the attenuated feedback voltage should be close to 5V. Should this voltage rise (due to an increase in the output voltage), the output of the error amplifier also rises and



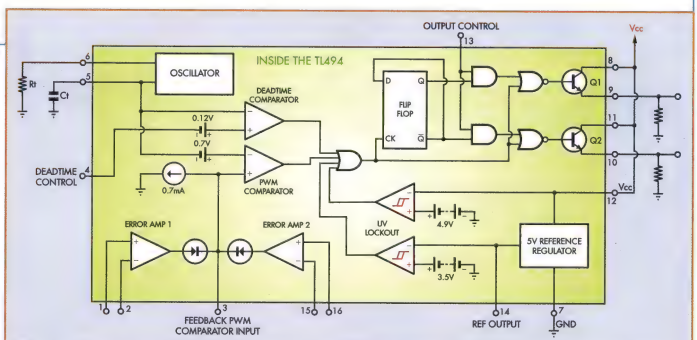


Fig.3: the internal circuit of the TL494 Switchmode Pulse Width Modulation (PWM) Controller. It is a fixed-frequency PWM controller containing a sawtooth oscillator, two error amplifiers and a PWM comparator. It also includes a dead-time control comparator, a 5V reference and output control options for push-pull or single-ended operation.

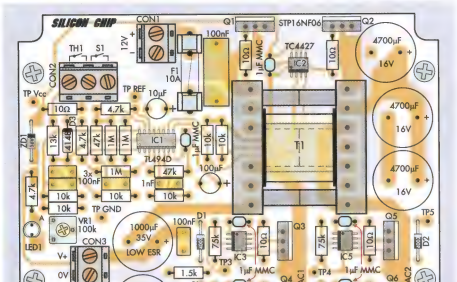


Fig.4: install the parts on the PCB as shown on this layout diagram, starting with the SMD ICs (IC1-IC6). Be sure to orientate the ICs, Mosfets, diodes zener diodes and electrolytic capacitors correctly

this reduces the output pulse width. Conversely, if the output falls, the error amplifier output also falls and the pulse width increases.

The gain of the error amplifier at low frequencies is set by the 1MΩ feedback resistor between pins 3 & 15 and by the 4.7kΩ resistor to pin 14 (V_{REF}). These set the gain to about 213. At higher frequencies, the gain is set to about 9.5 by virtue of the 47kΩ resistor and 100nF capacitor in series across the 1MΩ resistor. This reduction in gain at higher frequencies prevents the amplifier from responding to hash on the supply rails and ensures stability.

The 10kΩ resistor and 1nF capacitor at pins 6 & 5 respectively set the internal oscillator to about 50kHz. An internal flipflop divides this by two to give the complementary 25kHz output signals at pins 9 & 10. Note that while most of the inverter circuitry could run at much higher speed, "skin effect" in the windings of the ferrite-cored inverter transformer set the practical limit for switching the Mosfets to around 25kHz.

Pin 4 of IC1 is the dead-time control input. When this input is at the same level as V_{REF}, the output transistors are off. As pin 4 drops to 0V, the dead-time decreases to a minimum. At switch on, the 10µF capacitor between V_{REF} (pin 14) and pin 4 is discharged. This prevents the output transistors in IC1 from switching on. The 10µF capacitor then charges via the 47kΩ resistor and so the duty cycle of the output transistors slowly increases until full control is gained by the error amplifier. This effectively provides a soft start for the converter.

The complementary PWM outputs at pins 10 & 9 of IC1 are fed to Mosfet drivers IC2a and IC2b which drive the gates of Q1 and Q2. Note also the 100nF capacitor and the three 4700µF low-ESR capacitors between the centre tap of the transformer primary and the ground. These are included to cancel out the inductance of the leads which carry current to the transformer. They effectively provide the peak current required from the transformer as it switches.

Mosfet rectification

As previously mentioned, the AC from the transformer secondary is rectified by Mosfets instead of a conventional diode bridge. This increases the overall efficiency of the DC-DC Converter.

The rectification process employs both the intrinsic diodes of the Mosfets and their normal channel conduction. The intrinsic diode in a Mosfet is a reverse-connected diode that is part of the substrate layer. Originally, these intrinsic diodes were notoriously slow acting but are now quite fast. Now if the Mosfets were prevented from conducting, their intrinsic diodes are connected to operate in the same way as a conventional bridge rectifier. The Mosfets themselves are then controlled to act as "helpers" for each diode, switching on when the intrinsic diodes begin to conduct and switching off just before reverse conduction.

Each Mosfet is controlled using an IR11672 secondary side driver (SSD). Each SSD monitors the voltage across its Mosfet to determine when to switch the Mosfet on or off via its V_{GATE} output.

When the voltage between drain and source is greater than -50mV, the Mosfet is switched on to bypass the intrinsic diode. When the voltage drops below -6mV, the Mosfet is switched off.

Using the Mosfets saves valuable power compared to conventional diode rectifiers. For example, at a current of 3.5A, a Vishay V10150C Schottky diode would have a forward voltage close to 0.9V, resulting in a power loss of 3.15W for each diode.

By using the specified IRFB23N15 Mosfets, the voltage drop at 3.5A is less at 0.25V, giving a power loss of 875mW. Overall, the Schottky diode rectification would have a 6.3W loss compared to 1.75W for the Mosfet rectifiers; remember that only two diodes are conducting at any one time. The low power dissipation means that these Mosfets do not require heatsinking and the higher efficiency means less battery current for a given power output.

Of course, there is some power loss associated with the Mosfet drivers. This amounts to about 267mW for the four devices in the bridge.

The IR11672 includes a minimum on-period to prevent the Mosfet switching off immediately it switches on, which could otherwise happen due to the decreased voltage between drain and source. The minimum on time is set by the resistance at the MOT (Minimum On Time) terminal. Using the 75kΩ resistor, this is around 3µs.

Note that the IR11672 is designed for high-frequency switchmode supply rectification up to 500kHz.

Power for each IR11672 is derived from the -35V supply rail via a 1.5kΩ resistor that feeds 15V zener diode ZD2. The initial -35V supply is obtained by the rectification provided

by the intrinsic diodes in the Mosfets. Then, as each IR11672 receives a supply, rectification using the switched Mosfets begins. Both IC4 and IC6 share the same common 15V supply via ZD2. This is possible because these ICs also share the common -35V supply as their negative rail.

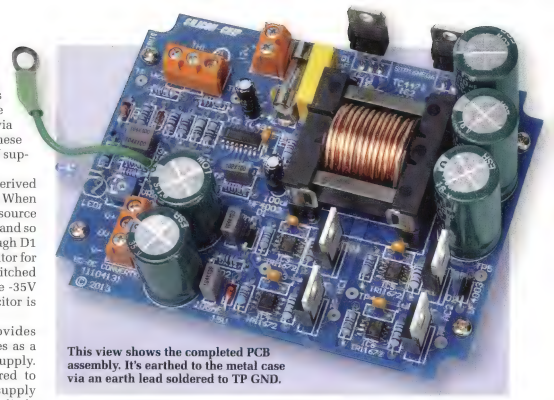
The supply for IC3 & IC5 is derived via diodes D1 & D2 respectively. When Mosfet Q4 is switched on, Q3's source is pulled to the -35V supply rail and so power from ZD2 can flow through D1 to charge the 1µF supply capacitor for IC3. Similarly, when Q6 is switched on, Q5's source is pulled to the -35V supply and IC5's supply capacitor is charged from ZD2 via D2.

Indicator LED (LED1) provides power indication. It also serves as a minimum load for the +35V supply. This minimum load is required to match the load on the -35V supply that delivers power to zener diode ZD2. Since it is the +35V supply that is monitored with IC1 for voltage regulation, the minimum load ensures that the PWM drive to maintain voltage regulation is sufficient to maintain the -35V supply.

For correct operation, it is important that this minimum load is not disconnected. So if LED indication is not required, the LED connections on the PCB should be bridged to ensure that the LED resistor is still connected between the +35V supply and ground.

Construction

All the parts for the CLASSiC DC-DC Converter are mounted on a double-sided PCB coded 11104131 and measuring 110 x 85mm. This fits neatly inside a metal diecast case measuring 119 x 94 x 57mm. The diecast case not only makes for a rugged assembly but also provides shielding plus heatsinking for Q1 & Q2.



This view shows the completed PCB assembly. It's earthed to the metal case via an earth lead soldered to TP GND.

CAUTION

It's a good idea to switch off and let the 1000µF output filter capacitors discharge (ie, blue LED out) before connecting (or disconnecting) this DC-DC Converter to an amplifier.

It's also a good idea to avoid touching the ±35V (70V total) supply rails during operation to avoid the possibility of a shock.

Fig.4 shows the parts layout on the PCB. Begin the assembly by installing IC1-IC6. These are all SMDs in SOIC packages and are quite easy to solder in place due to their (relatively) wide 0.05-inch pin spacing. Each IC is mounted on the top of the PCB and must be orientated as shown on the overlay diagram of Fig.4.

To solder an IC in place, align its leads over the PCB pads and tack solder pin 1 first. That done, check that the device is correctly aligned. If not, remelt the solder and adjust it as necessary. The remaining pins are then soldered, starting with the diagonally opposite pin (pin 16 or pin 8), after which you should resolder pin 1.

Don't worry if you get solder bridges between adjacent pins during this process. These bridges can be quickly cleared using solder wick – just press the solder wick against the bridge using a hot soldering iron. A dab of no-clean flux paste will aid this process.

Once all the ICs are soldered in, the next step is to install the remaining low-profile parts. Note that component values shown on Fig.4 are for a 12V supply. If you wish to use a 24V supply, then it will be necessary to change a few component values, as detailed in the accompanying panel.

Start with the resistors, diodes and zener diodes. Table 1 shows the resis-

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	3	1MΩ	brown black green brown	brown black black yellow brown
❑	4	75kΩ	violet green orange brown	violet green black red brown
❑	2	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	1	13kΩ	brown orange orange brown	brown orange black red brown
❑	7	10kΩ	brown black orange brown	brown black black red brown
❑	3	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	1	1.5kΩ	brown green red brown	brown green black brown brown
❑	7	10Ω	brown black black brown	brown black black gold brown

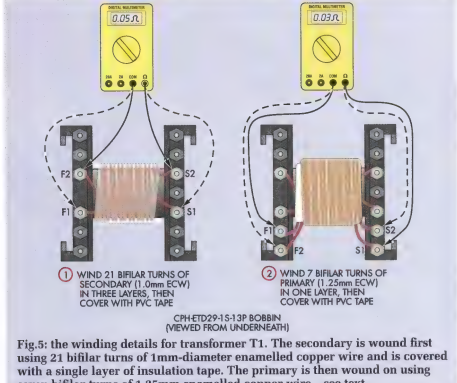


Fig.5: the winding details for transformer T1. The secondary is wound first using 21 bifilar turns of 1mm-diameter enamelled copper wire and is covered with a single layer of insulation tape. The primary is then wound on using seven bifilar turns of 1.25mm enamelled copper wire – see text.

Running The DC-DC Converter From 24V

Although we have not tested this DC-DC Converter at 24V, it can be done with some circuit changes. However, 24V operation is not ideal because the winding wire needs to be a smaller diameter so that the extra turns required can fit on the transformer bobbin.

For 24V operation, the secondary is wound with 21 turns of 0.8mm enamelled copper wire. The primary is then wound with 14 turns of 1mm enamelled copper wire. Note that this has to be run in two layers and so once completed, the wires will need to be run back across to the other side of the bobbin (ie, at right angles to the windings on the underside) to return the wire to the finish terminals.

In addition, the fuse must be changed to 5A, the capacitors changed from 4700µF 16V to 1000µF 35V, the 10Ω resistor for ZD1 changed to 1kΩ and the 13kΩ resistor at pin 2 of IC1 changed to 36kΩ. The parts list below shows the new parts.

Parts List Changes For 24V Operation

- 1 M205 5A fast blow fuse (F1) (instead of 10A)
- 5 1000µF 35V (instead of 3 x 4700µF 16V PC low-ESR electrolytic and 2 x 1000µF 35V PC low-ESR electrolytic)
- 1 1kΩ 0.25W resistor for ZD1 (instead of 10Ω)
- 1 36kΩ 0.25W resistor (instead of 13kΩ at pin 2, IC1)
- 1 2.6m length of 0.8mm-diameter enamelled copper wire for T1's secondary
- 1 1.8m length of 1mm-diameter enamelled copper wire for T1's primary

tor colour codes but you should also check the values with a multimeter, as some colours can be difficult to distinguish.

Be sure to orientate the diodes and zener diodes as shown on Fig.4. The zener diode type numbers are shown in the parts list.

The PC stake at TP GND is next on the list, followed by LED1. The latter is mounted with its leads bent down by 90°, so that its lens can later pushed through a matching hole in the side of the case. To install it, bend its leads down about 3mm from its body, then solder it in position so that the centre line of its body sits about 9mm above the PCB.

Be sure to install the LED with the correct orientation. Its anode lead is the longer of the two.

Mosfets Q1-Q6 can now go in. These should be installed so that the tops of their metal tabs are 20-25mm above the PCB.

Follow with the capacitors. The electrolytic types must all be orientated with the correct polarity (ie, with the negative side towards the left edge of the PCB). Once they're in, install trimpot VR1, then fit screw terminal blocks CON1, CON2 & CON3.

Now fit the fuse clips. These each have an end stop at one end, so that the fuse will not slip out when installed. Make sure these end stops go to the outside, otherwise you will not be able to later install the fuse.

Transformer winding

The PCB assembly can now be completed by winding and fitting the transformer. Fig.5 shows the winding details for the 12V version (refer to the accompanying panel for the winding details for the 24V version).

The secondary windings are wound on the bobbin first. Begin by cutting a 2.6m length of 1mm-diameter enamelled copper wire into two 1.3m lengths. That done, strip 5mm of the enamel insulation from one end of each wire using a hobby knife, then solder these wires to terminals S1 & S2 (start) as shown in Fig.5 (these go on the side with the seven terminals).

Now carefully wind on seven bifilar turns (ie, both wires laid side by side) to the opposite side of the bobbin, then another seven turns back towards the start terminals and finally another seven turns back to the opposite side (ie, 21 bifilar turns in all). Once all the turns are on, secure them in place using a single layer of insulation tape, cut to fit the width of the bobbin.

Now set your multimeter to read ohms and use it to determine which wire is connected to S1. That done, trim this wire to length, strip 5mm of enamel insulation from the end and solder it to terminal F1. The other wire is then connected to F2.

Finally, use your multimeter to confirm that there is close to zero ohms

between S1 and F1 and close to zero ohms between S2 and F2. Check also that there is a high impedance (>1MΩ) between the windings, eg, between S1 and S2.

The primary winding is also bifilar wound but consists of just seven turns of 1.25mm enamelled copper wire. Note that the orientation of the bobbin is also important when installing this winding.

First, check that the bobbin is orientated so that the side with the six terminals is to the left, as shown in Fig.5 (ie, with the terminals facing towards you). That done, cut a 900mm length of 1.25mm enamelled copper wire in half, strip one end of each wire and solder them to the primary S1 & S2 terminals.

Now wind on seven bifilar turns in the direction shown, taking care to ensure that the wires are close together (otherwise they won't fit into the bobbin). Cover this winding with another layer of insulation tape, then identify which wire connects to S1 and connect it to F1. The other wire is then connected to terminal F2.

Note that the primary F1 and S1 terminals are diagonally opposite each other, as are S2 and F2. By contrast, S1 and F1 are directly opposite each other for the secondary winding (as are S2 and F2).

Once again, use a multimeter to confirm that S1 and F1 are connected, that S2 and F2 are connected, and that there is a very high impedance between the two windings. Check also that there is no connection between any of the primary and secondary windings.

Once the windings are in place, the transformer assembly is completed by sliding the two ferrite cores into the bobbin and securing them in place using the supplied clips. The transformer can then be installed on the PCB.

Parts List

1 double-sided PCB, code 11104131, 110 x 85mm
1 diecast box, 119 x 94 x 57mm (Jaycar HB-5064 or equivalent)
1 ETD29 transformer (T1) (1 x 13-pin former [element14 Cat. 1422746], 2 x N87 cores [element14 Cat. 1781873], 2 x clips [element14 Cat. 178507]
1 thermostat switch (60°C, normally closed) (Jaycar ST-3821, Altronics S5600) (TH1)
2 IP68 cable glands, 4-8mm cable diameter
1 2-way screw terminals (5.08mm pitch) (CON1)
2 3-way screw terminals (5.08mm pitch) (CON2,CON3)
2 M205 PCB-mount fuse clips
1 M205 10A fast-blow fuse (F1)
1 SPST or SPDT toggle switch (S1) (optional – see text)
4 M3 x 9mm tapped spacers
2 TO-220 silicone insulation washers
2 insulating bushes
2 M3 x 10mm screws
6 M3 x 6mm screws
4 M3 x 6mm countersunk screws
4 M3 nuts
1 solder lug
1 2.6m length of 1mm enamelled copper wire (for T1 secondary)
1 900mm length of 1.25mm enamelled copper wire (for T1 primary)
1 length of 24/0.2mm (0.75mm^2 cross section) figure-8 cable
3 lengths of 19/0.18mm (0.48mm^2 cross section) or 14/0.2mm (0.44mm) wire
1 200mm length of medium-duty hookup wire
1 PC stake (TP GND)

Semiconductors

1 TL494CDR SOIC-16 Switchmode Pulse Width Modulation Controller (IC1)
1 TC4427ACOA SOIC-8 Dual Mosfet Driver (IC2) (element14 Cat. 1467705)
4 IR11672ASPBF SOIC-8 Smart Rectifier Controller (IC3-IC6) (element14 Cat. 1827123)
2 STP60NF06 N-channel Mosfets (Q1,Q2)
4 IRFB23N15DPBF 150V, 23A N-channel Mosfets (Q3-Q6) (element14 Cat. 8648735)
2 UF4003 fast rectifier diodes (D1,D2)
1 1N4148 switching diode (D3)
1 16V 1W zener diode (1N4745) (ZD1)
1 15V 1W zener diode (1N4744) (ZD2)
1 3mm blue LED (LED1)

Capacitors

3 4700µF 16V low-ESR electrolytic
2 1000µF 35V low-ESR electrolytic
1 100µF 16V electrolytic
1 10µF 16V electrolytic
6 1µF 50V monolithic multilayer ceramic (MMC)
1 100nF X2 class 275VAC MKP metallised polypropylene
5 100nF 63/100V MKT
1 1nF 63/100V MKT

Resistors (0.25W, 1%)

3 1MΩ	6 10kΩ
4 75kΩ	3 4.7kΩ
2 47kΩ	1 1.5kΩ
1 13kΩ	7 10Ω

1 100kΩ mini horizontal trimpot (VR1)

Preparing the case

You now have to drill holes in the diecast box to mount the PCB and to mount Q1 & Q2 and the thermal switch. Another hole is required for the LED, while two large holes are required to accept cable glands.

First, sit the PCB assembly inside the box and mark out the four mounting holes. Drill these out to 3mm in diameter and countersink them from the outside to suit the specified countersunk screws.

That done, attach four M3 x 9mm Nylon spacers to the PCB assembly using M3 x 6mm screws, then sit the PCB inside the diecast box. Once it's in position, mark out the mounting holes for the tabs of Mosfets Q1 & Q2 plus a hole at one end to accept the indicator LED.

Drill these out to 3mm in diameter, then slightly countersink the holes for Q1 & Q2 to remove any sharp edges. This is necessary to prevent damage to the silicone insulating washers that fit between the Mosfet tabs and the case (a sharp edge could puncture a washer and short a metal tab to the case).

The cable glands are placed 15mm down from the top of the case and 20mm in from the sides (see photo). The thermal cut-out is mounted midway between the two cable glands, with its top mounting hole 7mm down from the top edge of the case.

It's a good idea to solder an M3 nut to one lug of the thermal cut-out. This can then be used in the lower mounting position, making the unit easier to

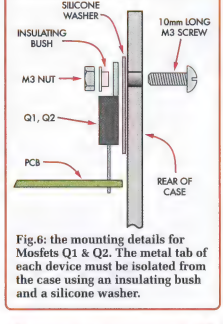


Fig.6: the mounting details for Mosfets Q1 & Q2. The metal tab of each device must be isolated from the case using an insulating bush and a silicone washer.

Using The Converter To Power The SC480 Amplifier

If you want to run a pair of SC480 amplifier modules using this DC-DC Converter, you can do so but they will give slightly less than their specified power output since they were originally designed to run from ±40V rails. However, they will run quite happily from ±35V.

attach when the PCB is in place.

Once all the holes have been drilled, install the PCB assembly in the case and secure it using four countersunk screws.

Attaching Q1 & Q2

Q1 & Q2 are each attached to the side of the case using an M3 x 10mm screw and nut, along with a silicone insulating washer and an insulating bush. Fig.6 shows the details. Do the screws up firmly, then use a multimeter to check that both tabs are correctly isolated from the case.

You can do this by measuring the resistance between the case and the Mosfet tabs. You should get a high ohms reading in each case but the meter may initially show a low ohms reading as various on-board capacitors charge up when the probes are connected. A permanent zero ohms reading means that there is a short which has to be fixed.

The case itself is earthed to the GND PC stake on the PCB via a short length of hook-up wire. That's done by first attaching a solder lug to one end of the wire, then attaching this to the case using the same mounting screw that's used to attach the top lug of the thermal cut-out. The other end of the wire is then soldered to the GND stake.

Once it's in place, fasten the bottom mounting lug of the thermal cut-out to the case, then solder two 80mm-long leads to its terminals and insulate these with heatshrink. The other ends of these leads can then be stripped and connected to the TH1 terminals on CON2.

The S1 switch terminals on CON2 can either be connected to an external switch or simply bridged with a short piece of tinned copper wire. The switch (or bridging wire) does not carry significant current (less than 50mA), since it doesn't carry the full DC-DC Converter current.

Basically, S1 is will probably only be needed if there's no power switch for the external power supply.

Completing the assembly

The assembly can now to completed by installing fuse F1 and connecting the power supply leads. The supply leads can be made using a suitable length of 24/0.2mm (0.75mm^2) figure-8 wire. Connect the striped lead to the negative terminal of CON1 and the other lead to the positive terminal.

You can use a pair of needle-nose pliers to push the wires into their terminals on CON1.

Testing

Before connecting the external supply, go over the assembly carefully and check that the parts are all correctly positioned. In particular, check that the electrolytic capacitors are the right way around as these things have a nasty habit of exploding if they are installed with reverse polarity.

That done, wind trimpot VR1 fully anticlockwise, then fit the lid on the case (just in case an electrolytic is in the wrong way around).

If possible, use a current-regulated power supply to initially test the DC-DC Converter. If you don't have one, then a non-regulated supply or a 12V battery can be used. Be sure to get the supply polarity correct; if you connect it the wrong way around, the fuse will blow.

Once it's hooked up, apply power and let the unit run for several minutes. If it powers up safely (ie, no explosions from capacitors), you can then remove the lid and check the voltages between the 0V and the +35V and -35V terminals on CON3. With VR1 wound fully anticlockwise, you should get around +10V and -10V on these terminals.

Assuming all is well, carefully rotate VR1 clockwise until you get +35V and -35V readings. **Do not set the outputs any higher than ±35V, as the output capacitors are not rated for higher voltages (ie, they only have a 35V rating).**

Finally, the three output leads can be made up using 24/0.2mm wire and connected to CON3. The other ends of these leads can then be fitted with coloured heatshrink sleeves to identify them: red for +35V, green for 0V (GND) and blue for -35V.

You new DC-DC Converter is now ready for use with the CLASSiC-D Amplifier. However, before connecting it up, the amplifier needs a few minor modifications in order to operate from ±35V rails – see the above panel. SC

Modifying The CLASSiC-D Amplifier For ±35V Rails

As presented in the November and December 2012 issues of SILICON CHIP, the CLASSiC-D Amplifier is designed for ±50V (or ±55V) supply rails. However, if you intend using this DC-DC Converter to power the amplifier, you need to make a few changes to the amplifier to suit the converter's lower ±35V supply rails.

This involves changing several resistors and zener diodes, as shown in Table 1 on page 68 of the December 2012 issue (ie, in the article describing the construction of the CLASSiC-D amplifier module). The new zener diode type numbers are also shown in this table.

Once the necessary parts have been changed in the amplifier, the supply wires from the DC-DC Converter can be connected to it using three lengths of 19/0.18mm (0.48mm^2 cross section) or 14/0.2mm (0.44mm^2) wire. Make sure the connections are made with the correct polarity.

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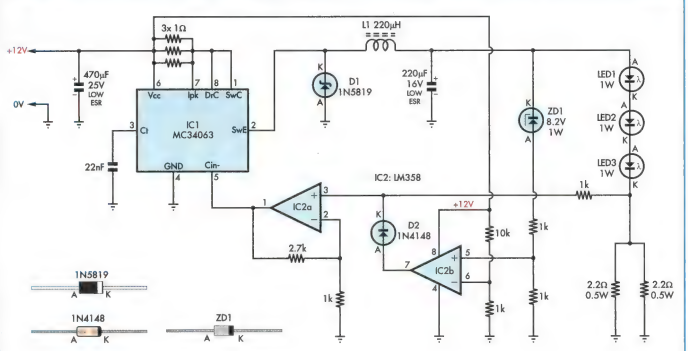
Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.



1W LED driver with protection

When driving 1W LEDs from a 12V supply you can either limit the LED current with a power resistor or use a switchmode current source. For three 1W LEDs in series, a suitable resistor would be 6.8Ω for a 12V supply, assuming 3.3V across each LED and 300mA current.

The power dissipation in the 6.8Ω resistor is 612mW. However, should the 12V supply rise to 14.4V when used in a vehicle, the current could rise to 660mA. This would severely over-drive the series LEDs, with the resistor dissipating almost 3W.

This LED driver provides a constant 300mA current with a DC supply ranging from 10-15V and is more efficient. IC1 is an MC34063 DC-DC converter that operates in step-down mode. The 220µH inductor is fed from pin 2 of IC1, the current then flowing via the three LEDs and the paralleled 2.2Ω resistors.

When IC1's internal transistor is switched off, diode D1 dumps the inductor's charge into the LEDs, maintaining the current though them.

Op amp IC2a monitors the voltage across the paralleled 2.2Ω resistors. With a LED current of 307mA, the voltage across these resistors is 338mV and this is amplified by 3.7 in IC2a to produce 1.25V at the comparator input of IC1. This input is compared against an internal 1.25V reference. The comparator controls the charging period for inductor L1 in order to maintain 1.25V at the comparator input and hence the 307mA current.

Peak inductor current limiting plus protection against a short circuit on the output is provided using three paralleled 1Ω resistors between the Vcc supply and IC1's Ipk sense input. When the voltage between Vcc and Ipk exceeds about 350mA, the inductor is switched off. Protection against an open circuit is provided by IC2. An open circuit can be due to, for example, a broken wire to the LEDs.

Normally, with the LEDs connected, the voltage at pin 6 is around 1.09V. The non-inverting input at pin 5 is at 0V and so IC2b's output is low and diode D2 is reverse biased and has no effect on the voltage at pin 3 of IC2a.

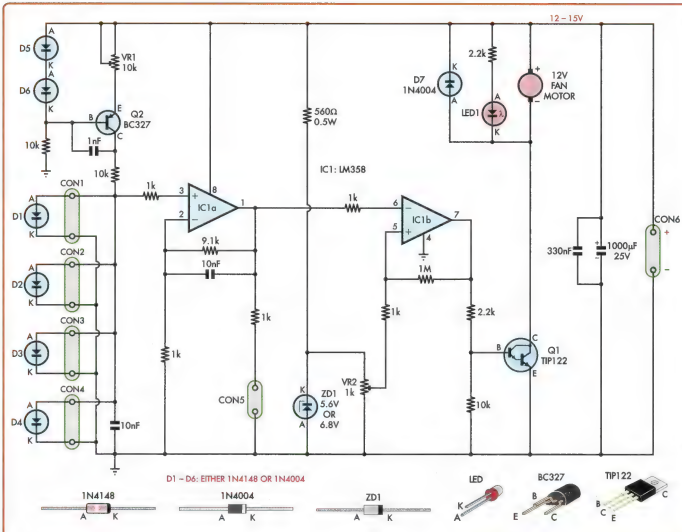
With an open circuit, the voltage across the 220µF capacitor can become very high, damaging both the capacitor and the LEDs should they be reconnected with this high voltage present.

With the protection circuit, a higher than normal voltage allows ZD1 to conduct, pulling pin 5 of IC2b higher than its inverting input. This occurs with about 1mA current flow through ZD1 and 1V across each 1kΩ resistor. So there is about 14V across the 220µF capacitor.

The now high output from IC2b's output drives IC2a's pin 3 input high. This also sets IC2a's output high, driving the comparator input higher than 1.25V and ensuring current to the inductor is switched off.

Inductor L1 is wound on a 15 x 8 x 6.5mm powdered-iron core (Jaycar LO1242), using 80 turns of 0.5mm enamelled copper wire.

John Clarke,
SILICON CHIP.



12V fan controller with up to four temperature sensors

This circuit allows the temperature of several components to be monitored while they are cooled by a single fan. Only one sensor needs to become hotter than the set temperature and the fan will be turned on.

Each sensor is based on a PN junction which may be a normal silicon diode or a silicon transistor with its base shorted to the collector (either NPN or PNP can be used). The accompanying table shows suitable transistors and diodes.

The circuit works on the principle that the forward voltage of a forward-biased PN junction is reduced by 2.2mV for every 1°C increase in temperature.

In our case, four such sensors are connected in parallel which means than the hottest junction will have the lowest voltage drop and it will control the circuit. More or less sensors can be connected, if need be.

Transistor Q2 and diodes D5 & D6 function as a current source to feed the four diode sensors which will share the supplied current set by trimpot VR1 to about 0.4mA.

The commoned sensor voltage is amplified by a factor of about 10 by op amp IC1a and then fed to op amp IC1b which functions as a comparator. It compares the amplified sensor voltage at its pin 6 with the reference voltage at pin 5, derived via trimpot VR2 from zener diode ZD1.

When pin 6 is below pin 5, corresponding to a hot sensor, the pin 7 output of IC1b goes high and turns on Darlington transistor Q1. This drives the fan. Alternatively, if pin 6 goes above pin 5, pin 7 goes low, Q1 turns off and the fan stops.

Depending on the current drawn by the fan, the Darlington transistor may need to be mounted on a small heatsink.

Petre Tzv. Petrov
Sofia, Bulgaria. ($60)

DIODE	NPN	PNP
1N4148, 1N914, 1N4001 ⋮ 1N4004	BC337, BC546, BC547, BC549, BC550, BC107, ETC.	BC327, BC556, BC557, BC559, BC560, BC177, ETC.

Either a normal silicon diode or a transistor (NPN or PNP) can be used as a temperature sensor. If a transistor is used, its base must be shorted to its collector.

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Serially controlled, expandable 7-segment display

This circuit is designed to form a 7-segment display module which can be easily driven from a microcontroller with a minimum number of pins. Each module has two digits but these can be daisy-chained to form as many digits as you require. They can still all be controlled using the same 3-wire or 4-wire serial bus which can even be shared with other SPI devices. PWM brightness control is also easily achieved using an extra pin.

The two 7-segment displays used are common anode types. The common anodes are connected directly to the +5V supply rail.

There are eight cathodes per digit (seven segments plus the decimal point), so 16 in total for the two digits. There is a series current-limiting resistor for each, the values being chosen to give around 10mA through each LED. The current-limiting resistor values may need to be changed depending on the exact display used, to give an appropriate brightness level.

The cathodes are driven by the outputs of two ULN2803 quad Darlington arrays. When a logic high is applied to each input, the associated output sinks current from the connected LED cathode. The saturation voltage of these outputs is around 1V so this should be taken into account when calculating current-limiting resistor values. For example, with a 5V supply and red LEDs in the display, you can expect around (5V - 1.8V - 1V) = 2.2V across the resistors and 2.2V ÷ 220Ω = 10mA.

The inputs of the Darlington arrays are driven by 74HC595 serial-to-parallel shift registers with output latches. These are daisy-chained with the serial output of IC1 feeding into the serial input of IC2.

So to set the state of the 7-segment display, 16 bits of data are shifted into IC1/IC2 using the serial data input (SDI) and serial clock (SCK) lines of CON1. During this process, the state of the 7-segment display does not change. It is only when a positive-going pulse is received on the register clock (RCK) line that the two digits change to show the new values. This occurs simultaneously across all digits, even if multiple modules are chained.

The CLR line can be pulled low to clear the contents of the shift registers but this does not affect the outputs until there is a positive-going pulse on the RCK line. In practice, unless you have a spare microcontroller pin, you can get away with just tying CLR high, ie, to the 5V supply.

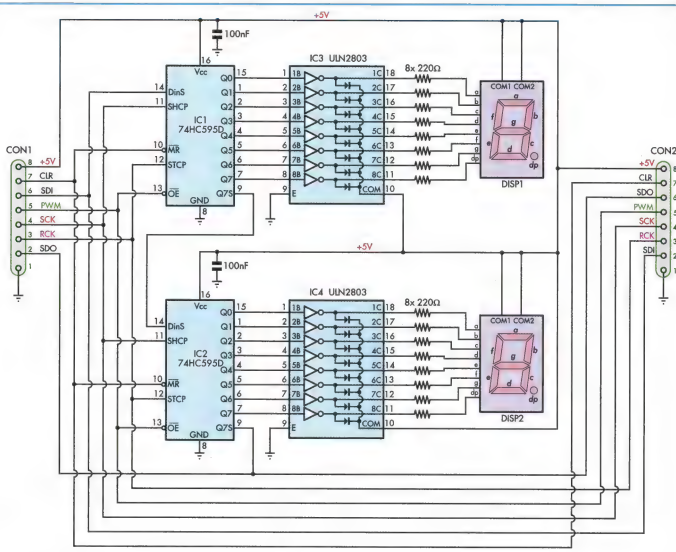
The PWM line can be tied low in which case the display runs at full brightness. Or it can be driven from the PWM output of a microcontroller running at 100Hz or higher. In that case, the low-level duty cycle (ie, the proportion of the time that this output is low) determines the display brightness.

Note that when this line is high, the outputs of IC1 and IC2 actually go high-impedance rather than low but because the IC3 and IC4 inputs are transistor bases, that will still reliably turn the display LEDs off.

CON2 is wired in parallel with CON1 except that the serial input and output lines are swapped. CON1 should be placed on the left side of the circuit layout and CON2 on the right, so that if modules are placed side-by-side, they can simply be wired straight through. That way, they share power and the serial bus is chained correctly. The micro then just needs to send 16 serial bits for each module connected on the SDI and SCK lines, then pulse RCK high to update the display.

In addition, if you want to use SDI and SCK to send serial data to other chips while RCK is idle, you can do that. This will shift data through IC1 and IC2 (and any other chained ICs) but since this will be shifted out by the new data you send before pulsing RCK, it doesn't matter.

Note that in general, it's better to use high-efficiency 7-segment displays to reduce the current drawn from the power supply. Also, you



can get units with two digits in a single housing although it's certainly possible to use two separate digits side-by-side.

The ULN2803s could be replaced with the more common 7-output ULN2003 if you don't need to be able to light the decimal points (or use discrete Darlington transistors to drive them).

You could run IC1 and IC2 off 3.3V if required to interface properly with your micro. However, you will probably need a higher voltage to drive the displays; even if the current-limiting resistor values are severely reduced, the display may still be too dim, depending on the exact type used.

Nicholas Vinen,
Silicon Chip.

SERVICEMAN'S LOG

A frustrating auto-electrical fault

Intermittent electrical faults in cars can be a real nightmare to track down. This one, in a Holden Epica, took several weeks to fix and then only after careful observation.

Our first story this month comes from J. H., of Nathan, Qld. He recently did battle with a car that suffered intermittent fuel pump failure because the supply line fuse kept blowing. Here's what happened . . .

Our troubles began at a picturesque lookout halfway up the Great Dividing Range between Mossman and Mt Molloy in Far North Queensland. We were on our way to Cooktown and had stopped to admire the view and take the obligatory photograph. Keen to be on our way, I then started the car, selected reverse and pressed the accelerator to back out of the parking space. The car hardly moved; instead, the motor just died and no amount of cranking the engine would produce the slightest sign of life.

The vehicle in question was a 2-year-old automatic Holden Epica with a diesel engine. It had been purchased new and had always performed flawlessly, so this present tantrum took me completely by surprise. It was also a bad place for it to throw its tantrum because we were now stuck in the middle of nowhere; well, almost.

From the lookout, we could see the coast and Mossman in the far distance and this allowed mobile phone contact with the RACQ. It was an hour's drive up the range from Mossman so all we could do was wait. Unfortunately, when the RACQ van eventually arrived, the mechanic was also unable to start the car. In the end, all he could do was go back down the range and return with a tow truck to carry our car back to civilisation.

And so, about three hours after the car broke down, we found ourselves sitting in the air-conditioned comfort of RACQ Mossman. Their auto-electrician gave the car a once over and found that the 15A fuse that protected the fuel pump had blown. When this fuse was replaced, the car ran perfectly and nothing could be done to make the fuse blow again.

Unable to give any rational explanation for the fuse failure, the auto electrician reverted to the time-honoured "weak fuse" explanation. However, I was far from convinced since this so-called weak fuse had lasted two years.

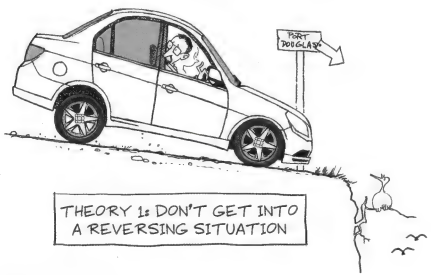
Because of my doubts, I asked the auto-electrician to give me some spare fuses in case the problem re-occurred. We then decided to find accommodation in Mossman for the night, as it was by now too late to proceed to Cooktown.

The next morning, we decided to cancel all our pre-booked accommodation at Cooktown and beyond and return home to Brisbane via the coast road where help would be easier to find if anything went wrong. I still had niggling doubts about the fuse problem and wanted easy access to servicing facilities.

All went well for about 1000km, at which point we decided to change drivers at a small pub just north of Mackay. We swapped over, my wife put the car into reverse, touched the accelerator and just as before, the engine died immediately. It turned out to be a replica of the previous fault condition – the same fuse had blown and when a new one was substituted the car again behaved normally.

Until that point, I had been having misgivings about cancelling our tour but now those misgivings flew out the window, along with the weak fuse theory. My new theory now was "don't get into a reversing situation", because that's when the problem seemed to occur.

We proceeded on to Brisbane (another 1000km) without further mishap, whereupon I phoned the local Holden dealer to arrange for warranty work to be undertaken. The service



Items Covered This Month

- Epica intermittent fuel pump problem
- Air conditioner repair
- Samsung Model 710V LCD monitor

section could not fit me in until after the forthcoming weekend but I wasn't unduly concerned by this. As long as I didn't violate the "no reversing theory", I would be able to use the car over the weekend.

Unfortunately, during a subsequent trip, it happened again but this time the car was moving forwards at about 60km/h when the engine suddenly died. I was able to pull over to the kerb and sure enough the same fuse had blown! This was a mortal blow to the "no reversing" theory but after replacing the fuse, I was able to gingerly drive home without further incident. I didn't venture out in it again until it was time to drive to the Holden dealer the following Monday.

The fault was diagnosed as an intermittent short in the fuel pump. A new one was duly installed and we all hoped that that would permanently fix the problem. Just to be sure, I took the car on a proving run of a few hundred kilometres the very next day. All went well and I was confident that the problem had now been fixed.

The next day, my wife had a doctor's appointment and it was while we were on our way to the surgery in heavy traffic that the engine died again. The same fuse had blown again and replacing it got us going again. I then dropped my wife at the surgery and proceeded down to the river to find a shady park while I awaited her call to come and pick her up.

On reaching the river bank, I found that the trees were all on the other side of the road, so decided to make a 3-point turn to park in the shade. And right in the middle of this 3-point turn, the fuse failed again, leaving me at right angles to the kerb and blocking oncoming traffic.

I quickly changed the fuse but as soon as I touched the accelerator to reverse, the fuse again failed and I was now out of fuses! There was nothing for it but to call RACQ. They sent a van out and I explained the nature of the problem. A new fuse was installed but it too immediately failed, as did two more that were fitted in quick succession.

In the end, we called a tow truck to get the car back to the Holden dealer.

Just what was going on? Neither I nor the dealer had the slightest clue. A week passed and the car was still in dock. The trouble was the intermittent nature of the fault. The dealer couldn't get the car to exhibit the fault again and yet it had blown several fuses in succession when I had attempted that 3-point turn.

It was while they were investigating the fuse problem that the car's transmission developed a fault. It could no longer be put into reverse. Was this related to the fuse problem or a red herring? The service manager thought the former, replaced the transmission and declared the car fixed. The car had now been with them for several weeks and I guess they were keen to get it out of their hair. And just to be sure, the auto-electrician drove the car for a couple of days without incident before handing the car back.

I spoke to the auto-electrician but he was not as sure as the service manager that the fault had been found as he couldn't find a smoking gun. There was just no tangible link between the two faults. The problem was the inability to replicate the fault condition. No one knew for sure whether the fuse blowing fault was just lying dormant or had been fixed by replacing the transmission.

The doubts expressed by the auto-electrician prompted me to ask for a couple of spare fuses – just in case.

The answer came a week later. I was attempting to park on a sloping street but when I tried to reverse up the slope, the car refused to do so. It would go back half a metre then slip forward two metres. I quickly applied the brakes and turned the engine off, thinking that perhaps the new trans-

mission needed a band adjustment on reverse.

I restarted the engine and tried to reverse again with the same result, except that this time the engine quit. You guessed it, the fuse had blown again. Then all the pieces started to come together. The fault was being triggered somehow when the engine was under load, mainly in reverse gear. Of course, there were lots of other times when the car was reversed without blowing the fuse but these all involved reversing slowly on level ground, such as out of my garage or a shopping-centre parking space – conditions that put only a light load on the engine.

It now occurred to me that on each occasion when the car broke down in reverse gear, there had been some additional load placed on the engine. Certainly on the range near Mossman there was a significant slope to reverse up. Near Mackay, there was a smaller slope but much harder acceleration was involved. And during the 3-point turn, my front wheels had been in the gutter and the camber in the road had to be overcome.

So what about those occasions where the engine failed while the car was going forwards? There were two such occasions and on thinking back, those situations involved travelling downhill with the engine acting as a brake. The Epica's auto transmission can be manually up or down-shifted and I do this regularly in hilly Brisbane.

So it appeared that loading the engine by braking could trigger the fault but everything was perfectly OK while ever the engine was pulling the car forwards. And why might this be significant? Well, the engine tends to twist one way or the other on its mounts depending on the loading. It's one way during engine braking or when reversing and in the opposite direction during normal forward motion.

Armed with this new insight and the knowledge that the fault could perhaps be now made to appear at will, I replaced the fuse and drove straight back to the Holden dealer. I can't say they were happy to see me again; after all, they had already fitted the car with a new fuel pump and a new transmission.

Anyway, I invited the auto-electrician to back the car up a steep ramp and sure enough, the fault exhibited itself in all its glory. He was understandably much happier now he had a means of bringing on the fault at will.

It didn't take him long to find the culprit. A wire in the offending fuse's circuit was routed so that it passed very close (too close) to the engine (either the exhaust or some other hot part). And when the engine twisted under load, it came into contact with this wire. Over time (two years), the vibration and heat had worn away the insulation, thereby causing a short and blowing the fuse.

Conversely, with normal forward loading of the engine, it would twist in the opposite direction away from the wire and the car behaved normally. Perhaps if I hadn't been using engine braking so much, this situation may not have arisen but that's hardly the point. In any event, the Holden dealer sent an advisory note to other dealers to be on the alert for similar symptoms.

On taking delivery of the car, I pessimistically asked for a couple of spare fuses – just in case. It is now two months later and I haven't had occasion to use them.

Air-conditioner repair

N. K. of Kedron, Qld recently saved himself a heap of money by fixing the controller board in his broken-down air-conditioner. Here's his story . . .

Eleven years ago, we decided to buy several air-conditioners for our home. The layout of the living room was a challenge when it came to choosing a suitable unit but after some research, we eventually found a 6kW floor-standing cabinet-style split unit that was perfect.

Last year, on an unusually cold day, it was running on reverse-cycle heating when I heard a loud "pop" from the outdoor unit. The air-conditioner then immediately stopped, so I decided to see if I could determine what was wrong before calling the installers.

After opening the circuit breaker and power switch, I took the cover off the outdoor unit and the evidence was immediately visible. A 40 x 28mm transformer on the controller circuit board had a large hole in its side, accompanied by the usual black scorch marks.

I called the installers who came out and said they would try to find a replacement controller board. Unfortunately, after months of getting the run-around, I learned that they were

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unable to get the part. I then called the Australian distributor to see if they could source a replacement board or transformer, or at least supply a circuit diagram. It turned out that they had taken over the brand long after my model had been made obsolete and they were unable to help.

My next step was to search the internet to see if I could turn up a replacement part but I had no luck there either. So after just 11 years of faithful service from its corner location, it looked like this unit would end up in recycle hell. What's more, I couldn't find a similar new unit to fit our living room, so it seemed I was doomed to pay around $3500 for a less-than-ideal solution.

I unhappily mulled over this for many weeks while the summer temperatures gradually increased and my wife's patience correspondingly decreased. Then one night, inspiration kicked in and I decided to have a go at fixing it myself at the component level. After all, I had nothing to lose but time and parts.

Before starting, I took photos of the controller board with its 14 connectors and of the general wiring, including all the power connections, so I could reassemble it later. I then disconnected the power leads coming into the unit and insulated them, in case I got careless with the circuit breaker.

After removing the controller board, I de-soldered and removed the power transformer. It had one primary and six secondary windings, all isolated from each other. That done, it was time to trace out the various circuits on the board. This proved straightforward, as it was a large single-sided board with the usual vacant bands between the hot 325V DC areas and the low-voltage areas.

It was important to work out what the transformer did and try to understand how it failed. In particular, I wanted to figure out if the microcontroller or other irreplaceable parts had possibly been damaged, making repair impossible.

I traced enough of the circuitry to learn that the transformer fed power to the controller board itself, as well as providing four floating supplies that headed off to the inverter module. The power input for the transformer was derived from the same large 325V DC supply that supplied the inverter.

A single-transistor oscillator drove the primary of this transformer, with one of the transformer secondaries providing the feedback winding. I presumed that the switching transistor had failed first, resulting in a continuous 325V DC being applied across the primary. This also suggested that the supply-line fuse that's intended to save the transformer in this situation didn't blow until after the transformer had "exploded".

If this theory was correct, the damage would be confined to the primary (hot) side of the transformer only. The transistor, fuse and other components on the primary side could be replaced but finding a direct replacement for the custom transformer would be impossible.

Initially, I thought about rewinding it so I started breaking off some of the epoxy potting. This revealed tight, machine-wound secondary windings, with the primary as the inner winding. It soon became obvious that if I removed the secondaries, it was unlikely that I would be able to get hand-wound windings to fit back onto the core – all this with sufficient high-voltage isolation

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Serviceman's Log – *continued*

Samsung Model 710v LCD Monitor

In January this year, my Samsung monitor started playing up by blanking out the screen and displaying the message "Not optimum mode. Recommended mode: 1280 x 1024 60Hz". This message "danced" around the screen.

Both the monitor and computer are about nine years old but have not really done many hours. After some fiddling around, I discovered that the problem seemed to be heat-sensitive and was getting worse.

To prove this point, I popped the monitor into the fridge for 15 minutes and it then ran for 22 minutes before the fault appeared.

I was subsequently told that the monitor was "not worth repairing". It would be cheaper to buy a new (better) monitor than to pay someone to fix the faulty unit. In the end, I decided to have a go at it myself and what better place to start than the internet. After wading through about 12 pages of Google results using the search "Samsung 710v", I soon realised that quite a few people had the same problem with this monitor. Inevitably, there was a lot of "uninformed comment" but eventually I came across a web page at **monsieurmaggot.com/Samsung.html** which explained the fault, gave a logical reason for the cause and (better still) described a simple cure.

It appears that the smaller of the two large ICs on the monitor's PCB contains a resistor that fails with age/heat. The fix was to simply solder a 50Ω resister between pins 5 & 6 of this IC.

The first job was to dismantle the monitor. This was done by placing it face-down on a a soft towel, then undoing the four screws securing the stand and then another two screws close to the bottom edge. Prying off the front bezel with a small screwdriver then allowed the panel to be removed.

The next step was to release the metal back cover and that's done by removing the four small screws at the top and bottom of each side, plus the two screws holding the pushbutton strip at the bottom of the screen. The strip was then carefully lifted out. The cable from the pushbutton strip goes through a hole in the metal back cover to a connector on the circuit board and this has to be disconnected when lifting the back off.

Soldering in the new resistor was almost an anticlimax! And most importantly, the monitor worked normally after it was reassembled.

between them. And that was assuming I could break off all the epoxy without making the windings uncountable or fracture the core.

As a result, I abandoned any idea of rewinding the transformer and began to consider other alternatives. Eventually, I came up with the idea of using five separate power supplies to replace the failed multi-output supply.

The outputs from the five secondaries each fed a diode half-wave rectifier, with filtering by an associated electrolytic capacitor. One supply fed the board itself (which carried the 60-pin microcontroller) and this supply was regulated by a 7805 5V regulator.

I couldn't read the labelling on the microcontroller but it has outputs to switch the inverter. It also drives relays for the fan, among other things, and has lots of sensor inputs. Because the 7805 had no heatsink, I guessed about half an amp would be a high enough rating for an external supply, so I chose a 9V 5W unregulated switchmode plugpack to feed this regulator.

There was no way to determine the voltages (or currents) that the other four power supplies were supposed to deliver. As with the supply to the board, the electrolytic filter capacitors were all rated at 40V and I guessed that the filtered voltage would probably be less than half that figure. What's more, the small rectifier diodes used again suggested that the current would be less than 0.5A.

Anyway, I gambled on four 12VDC 5W unregulated switchmode plugpacks. Their open circuit voltage starts at around 14V and the original circuits for these supplies were not regulated. The next step was to securely mount them. I found sufficient room in the fan compartment of the air-conditioner to secure a waterproof ABS box and glued all five plugpacks, pins up, inside this box. I then fed the five low-voltage leads through a waterproof cable gland and a mains-rated lead through a second gland and secured it with a clamp. This lead was then soldered to the respective plugpack pins and heatshrink fitted over each pin for safety, even though the supplies are fully enclosed inside the box.

Most 230VAC switchmode power supplies (including switchmode plugpacks) are comfortable running on 325V DC. It means that two of the bridge diodes always conduct and two don't, so none of them have the stress of cycling. Also, the main filter capacitor and other components do not have to deal with the usual 50Hz harmonics.

As a result, the 325V DC line that previously went to the old power supply was now connected to the lead into ABS box that ran to the plugpack pins (ie, to run the plugpacks from 325V DC rather than from the 230VAC mains). I then soldered connectors on the controller board where the transformer secondary terminations had been, so I could plug in the appropriate outputs from the plugpacks.

Because the plugpack outputs are already DC, the half-wave rectifier diodes were no longer needed so I soldered a jumper across them to short them out.

The outdoor unit has spinning fans and high voltages, so there was no easy way to test the unit until it was all safely assembled and installed. As a result, I reinstalled the controller card with its burnt-out supply left idle and plugged the outputs from the five new DC supplies into the new connectors.

After reconnecting the mains and starting it, everything immediately worked – to my great relief. Fortunately, there was no other damage and I had accurately guessed the required voltages.

So the recyclers aren't getting their hands on my air-conditioner this time around. By investing just $100 in parts, I saved the $3500 cost of a new unit and avoided a messed up living room. And I (marginally) improved our national balance of trade. SC

Jaycar Electronics
Better, More Technical

MAY MAKERS

RESULTS OF THE MAKERS COMPETITION

Scan here to see results

Earlier this year we ran a competition for our customers to submit their inventions and projects made using Jaycar products. We were so impressed with the entries that we rewarded ALL entrants with a $100 gift card.

The complete list of entrants, along with their inspirational projects, can be viewed at www.jaycar.com.au/makers or by scanning the QR code to the right with your Smartphone or Tablet. We've featured most of the projects in our 2013 catalogue, along with a few across the following pages. A special mention needs to go to high school student Nathaniel McTaggart's Suit Controlled Humanoid Robot (shown here), Pero Van Der Merwe for the Motion Detection Cat Repellent Water Gun and James Watson for the Rubik's Cube Solving Robot. These three entrants have each received a $500 gift card.

Congratulations to the lucky entrants and thank you for your participation.

Visit www.jaycar.com.au/makers

Portable Metal Detectors

Attention treasure hunters! Two new metal detectors ideal for beach combing and prospecting. For a variety of different landscapes and each senses the presence of metal objects. Both require 6 x AA batteries.

Portable Metal Detector
- Waterproof search coil
- Can detect a 10 cent coin at up to 120mm depth
- Adjustable Length: 600 to 880mm

QP-2301

$59.95

Portable Metal Detector with LCD Display
- Shows the type of metal found and at what depth
- Can detect a 10 cent coin at up to 150mm depth
- Adjustable forearm brace, and padded handle
- Adjustable Length: 1080 to 1300mm

QP-2303

$149.00

Do Not Disturb Phone Timer Kit

Stop those annoying and intrusive phone calls when you don't want to be disturbed, say at meal or nap time for example. Set the timer duration between 15 to 120 minutes and the caller will get an engaged signal until the timer times out. Kit supplied with silk-screened PCB, black enclosure (83 x 54 x 31mm) with label, pre-programmed PIC, PCB mount components and phone lead.

NEW $29.95

- Five times settings: 15, 30, 60, 90 and 120 minutes
- Automatically returns phone to "ready" (on hook) after time-out
- Easy push-button timer setting
- No batteries required
- Works with multiple phone extensions in house.

KC-5521

Note: Phone not included

Due Late May

10MHz Handheld Scope DMM

Smartly combines a well featured digital oscilloscope and a 4,000 count True RMS digital multimeter into one versatile package. Features a USB interface and PC logging software to match. Perfect for laboratory work or for technicians working in the field.

- 128 x 128 graphic LCD display
- Autoranging
- Size: 186(L) x 86(W) x 32(D)mm

QM-1577

NEW $399.00

Soldering Iron Starter Kit

The ideal starter package for electronics enthusiasts or the home handyman, this kit contains everything needed for working on basic electronics projects or automotive circuits. Includes a digital multimeter, soldering iron, de-soldering tool, screwdrivers, pliers and side cutters.

NEW $34.95

- 25W

TS-1652

Gas Torch

Very versatile and ideal for brazing, silver soldering, jewellery work, plumbing or general hobby use.

- 1,300°C adjustable flame
- Size: 155(H) x 35(Dia.)mm

TS-1660

$39.95

40A Laboratory Power Supply

A high-powered switchmode power supply that will deliver up to 40 amps. It has a variable output voltage from 3 to 15VDC, or it can be fixed at 13.8VDC. The unit has overload, over temperature and over voltage protection.

$299.00

- Size: 220(W) x 110(H) x 300(L)mm

MP-3090

Digital Wireless Surveillance Camera Kits

Easy to install surveillance systems for the home or office, which use 2.4GHz DIGITAL technology to minimize interference and maximise range. Available with a rechargeable 7" LCD screen receiver for viewing video on the go or with standard receiver for connection to an existing TV screen. Both versions can also record video to playback after an incident by adding an SD card (sold separately). Power supplies included.

Receiver Features:
- Quad camera or single camera view
- Supports up to 4 cameras
- Accepts SD cards up to 32GB (sold separately)
- AV output for connection to separate monitor

Camera Features:
- Range up to 100m line of sight
- CMOS 380TV Lines
- IR illumination distance up to 5m
- Weatherproof IP66 housing
- Size: 130(L) x 65(Dia)mm

Camera with Standard Receiver
- Size:113(L) x 113(W) x 20(H)mm

QC-3672 ***was $249 now $199 save $50***

Camera with LCD Receiver
- 7" LCD screen
- Includes a rechargeable Li-ion battery
- Size: 190(W) x 113(H) x 20(D)mm

QC-3670 ***was $349 now $299 save $50***

Additional cameras available separately

QC-3674 $149.00

FROM $199.00
SAVE $50

Jaycar Underwood

WE ARE MOVING
70m down the road!

3263 Logan Rd
Underwood QLD 4119
Ph: 07 3941 4888

Ample parking available right outside and now twice the size!

To order call 1800 022 888 ***www.jaycar.com.au***

Jaycar Electronics — POWER MAKERS

Better, More Technical

High Power Modified Sine Wave Inverters

Save on our general purpose high power inverters ranging from 800 to 2000 watts capable of running small electrical appliances to running a microwave in a motor home.

- Electrically isolated for safety

800W MI-5110 ***was $189.00 now $169.00 save $20.00***
1000W MI-5112 ***was $249.00 now $229.00 save $20.00***
1500W MI-5114 ***was $399.00 now $379.00 save $20.00***
2000W MI-5116 ***was $499.00 now $479.00 save $20.00***

FROM $169.00 SAVE $20

Note: Other models available

Jaycar - No. 1 for Kits

Soft Start Kit for Power Tools

Ref: Silicon Chip Magazine July 2012

Stops that dangerous kick-back when you first power up an electric saw, router or other mains-powered hand tool. This helps prevent damage to the job or yourself when kick-back torque jerks the power tool out of your hand. Kit supplied with PCB, silk screened case, 2m power cord and specified electronic components.

$49.95

- 240VAC 10A
- PCB: 81 x 59mm

KC-5511

10A 12VDC Motor Speed Controller

Refer to Silicon Chip Magazine July 1997

Ideal for controlling 12V DC motors in cars such as fuel injection pumps, water/air intercoolers and water injection systems. You can also use it for headlight dimming and for running 12V DC motors in 24V vehicles. The circuit incorporates a soft start feature to reduce inrush currents, especially on 12V incandescent lamps. Includes PCB and all electronic components.

- Kit includes PCB plus all electronic components to build the 10A version.
- PCB: 69 x 51mm

$24.95

KC-5225

12A 24VDC Motor Speed Controller

Refer to Silicon Chip Magazine July 2011

Control the speed of 12 or 24VDC motors from zero to full power, up to 20A. Features optional soft start, adjustable pulse frequency to reduce motor noise, and low battery protection. The speed is set using the onboard trimpot, or by using an external potentiometer (available separately, use RP-3510).

- Kit supplied with PCB and all onboard electronic components
- Suitable enclosure UB3 case, HB-6013 sold separately

$39.95

KC-5502

USB Power Bank

Features a USB charging port and lead with 3 connectors for charging all variety of Smartphones, Tablets and USB charged devices. The device itself can be recharged with the supplied micro USB to USB cable.

$34.95

- Size: 76(L) x 33(W) x 29(D)mm

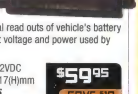
MB-3642

Digital Car Power Adaptor

Offers 7 different DC voltages with 3A continuous output, plus a USB charging output suitable for the latest Smartphones and iGadgets. The display provides accurate digital read outs of vehicle's battery voltage, selected output voltage and power used by the load.

- 1.5/3/4.5/5/6/7.5/9/12VDC
- Size: 98(L) x 57(W) x 17(H)mm

MP-3673 ***was $69.95***



$59.95 SAVE $10

Fast Battery Charger

Charge up to four AA or AAA Ni-MH or Ni-CD rechargeable batteries. Over-current, over-heat and over-voltage protection. Detects non-rechargeable, short-circuited or defective batteries.

$14.95

- Mains powered
- Size: 100(L) x 64(W) x 25(H)mm

MB-3564

Outdoor USB Solar Charger

Provides a 5V USB port suitable for charging devices such as media players and Smartphones. Attach it to a backpack, tent, or bike using the elastic strap and clips to charge on the go.

$44.95

- Output Voltage: 5VDC
- Size: 250(H) x 170(W) x 15(D)mm

MB-3593 Note: iPhone® not included

Variable Speed PCB Drill Press Maker Project

Makers Name: Craig Turner Location: Queensland

"This press features a work light, and a high speed motor and gear box assembly from a salvaged battery drill which is controllable from approximately 30 rpm to a rough guestimate of approximately 700 rpm using a 20A speed controller kit. To power the drill press, I designed a high current, multi-voltage power supply. I achieved this by relocating the output wires into the box and adding a switch to turn the power supply on."

For more details scan the QR code or go to www.jaycar.com.au/makers

Switchmode Power Supplies

20% OFF

These switchmode power supplies offer high efficiency and reliability. Features overload protection and current limitation, screw down terminals and strong metal case.

- Built-in EMI filter

25W 12V was $54.95 now $43.96 save $10.99
MP-3102
25W 24V was $54.95 now $43.96 save $10.99
MP-3103
40W 12V was $69.95 now $55.96 save $13.99
MP-3104
40W 24V was $69.95 now $55.96 save $13.99
MP-3106
60W 12V was $74.95 now $59.96 save $14.99
MP-3107
60W 24V was $74.95 now $59.96 save $14.99
MP-3109
60W 5V & 12V Dual Output was $79.95 now $63.96 save $15.99
MP-3108
100W 12V was $84.50 now $67.60 save $16.90
MP-3121
150W 12V was $109.00 now $87.20 save $21.80
MP-3110
150W 15V was $109.00 now $87.20 save $21.80
MP-3112
150W 24V was $109.00 now $87.20 save $21.80
MP-3114
240W 13.8V was $219.00 now $175.20 save $43.80
MP-3118

FROM $43.96

NOTE: These are not stand alone units. They have exposed 240V terminals. They are meant to mount inside secure, earthed cabinets.

Power Protection

Always keep your mains equipment protected! These powerboards provide power overload and surge protection and are perfect for home theatre, PC, AV systems etc.

- Extra-wide spacing on end socket to take mains plug packs
- Individually switched

FROM $19.95

4-Way MS-4064 $19.95
6-Way MS-4066 $24.95

Desktop Style Power

48VDC - 65W

48V power supply specifically designed for power over Ethernet applications.

- 48V @ 1.35A

MP-3249

$59.95

12VDC - 120W

Suitable for various power requirements, including large surveillance system to replace a number of smaller plugpacks.

- 12VDC @ 10A

MP-3241

$79.95

Note: Includes IEC lead

To order call 1800 022 888

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/05/2013.

SOLAR MAKERS

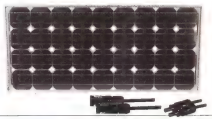
Recreational Solar Panel Packages

Clean renewable energy wherever you go. Convert your 4WD or caravan to generate sufficient solar power to operate several appliances - 12V camping essentials and luxuries etc. Just add a battery for a self-sustained setup. Two versions to choose from:

More Recreational Solar Packages available that suits your needs. See in store or on our website for more details

80W Standard Solar Package
- 1 x 80W monocrystalline solar panel
- 1 x 12V 8A charge controller
- 2 x female PV connectors
- 2 x male PV connectors

ZM-9300 ***was $300.00***



$280.00 SAVE $20

120W Premium Solar Package
- 1 x 120W monocrystalline solar panel
- 1 x 12V 8A PWM charge controller
- 2 x female PV connectors
- 2 x male PV connectors

ZM-9301 ***was $430.00***

$390.00 SAVE $40

Regulators and Chargers

12V 8A Solar Charge Controller

Suitable for both wet-cell and sealed lead-acid batteries and uses pulse width modulation for optimal 3-stage charging. See our website for full specifications.

- Size: 97(L) x 46(W) x 26(H)mm

MP-3720

$49.95

12V Super Solar Panel Regulator

Lightweight, easy to install and does not require a heatsink. Features automatic operation, LED power indication and boasts an efficiency up to 99.2% @ 20 amps.

- Battery or solar power LED indication
- Size: 66(L) x 51(W) x 34(H)mm

MP-3126

$79.95

12VDC 15W Solar Battery Charger

NEW LOWER PRICE

Keep batteries charged! Amorphous type panel capable of supplying current up to 1 amp, suited to a wide range of charging applications.

- Blue LED power indicator
- Strong ABS frame
- Size: 950(L) x 340(W) x 18(H)mm

ZM-9045 ***was $129.00***

$89.00 SAVE $40

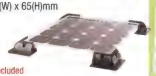
Solar Panel Corner Mounts

A set of four corner mounts, to attach each corner of your solar panel to your desired mounting surface. These can be used on their own for solar panels 40W or smaller.

- Size: 150(L) x 150(W) x 65(H)mm

HS-8850

$49.95



Note: Solar Panel not included

Solar Panel Mounting Bracket

Securely mount solar panels individually to a fixed surface, such as the roof of a caravan, motor home, shed, etc, with the necessary spacing for airflow underneath.

- Includes M6 bolt & nut
- Size: 80(L) x 68(W) x 35(H)mm

HS-8780

$7.95 EA

Solar Panel Angle Mounting Brackets

An ideal solution for mounting a single solar panel so that it can tilt at a desired angle and easily fold it back down again when not in use. Holes are pre-drilled to line up with common panel sizes such as 80W, 120W and 200W.

- Size: 670(L) x 30(W) x 60(H)mm, folded

HS-8785

NEW **$59.95**

Renewable Energy Book- Design Installation and Use

Explains renewable energy in an easy-to-read and understand format and covers everything from basic electrical concepts through to system design.

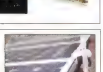
- Softcover, 201 pages, 280 x 206mm

BE-1538

$38.95

Photovoltaic Solar Panel Cooler Maker Project

Makers Name: Michael Porter ***Location: Victoria***



"PV solar panels produce more electricity when cooled. This device cools the panels using electrically-controlled garden irrigation water sprays. When cooling, the panels produce around 20% more power compared to the same conditions without cooling. It would be wasteful to run the water continually, so instead, a microcontroller is used with sensors measuring the panel and ambient temperatures to only use water when needed."

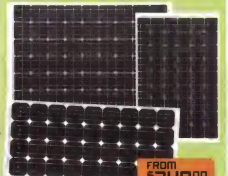
For more details scan the QR code or go to www.jaycar.com.au/makers

Powertech Solar Panels

Our Powertech Monocrystalline solar panels offers the same robust construction and performance as the leading brand names, whilst also offering a nice cost saving against the big brands. Built and suited to withstand harsh Australian conditions. See our website for full specifications.

- 12V

80W ZM-9097
was $289.00 now $249.00 save $40.00
90W ZM-9086
was $325.00 now $279.00 save $46.00
120W ZM-9098
was $425.00 now $369.00 save $56.00



FROM **$249.00** SAVE $40

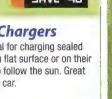
12V Solar Battery Chargers

Weatherproof solar panels ideal for charging sealed lead acid batteries. Mount on a flat surface or on their brackets so it can be moved to follow the sun. Great for use on a yacht, boat or in a car.
Two models available:

12V 1.26W
- Max current: 70mA
- Panel Size: 159 x 175 x 17mm

ZM-9016 ***was $44.95***

$34.95 SAVE $10



12V 4.5W
- Max current: 250mA
- Panel size: 187 x 255 x 17mm

ZM-9018 ***was $99.95***

$79.95 SAVE $20

MOTHERS DAY – 12th MAY

Mum's Kitchen Helpers! Countdown Timer

Use it for cooking, parking, exercising, studying or even timing the kids on the computer. Water resistant, easy to use, has a memory setting for frequently used values.

- Countdown range 99 hours 99 minutes 99 seconds
- Batteries included
- Size: 88(W) x 130(H) x 22(D)mm

XC-0271

$24.95

Kitchen Voice Recorder

Mum can use it for her shopping list, as a reminder for the kids or even to record the ingredients in those quick cooking commercials.

- 3 folders up to 50 messages
- Digital clock
- Requires 2 x AA batteries
- Size: 130(L) x 66(H) x 17(W)mm

XC-0249 *was $34.95*

$29.95
SAVE $5

2.4GHz Wireless DIGITAL Baby Monitor

100% DIGITAL in which it avoids interference from other electronic devices. The unit has a built-in infrared night vision, for round the clock monitoring and is wireless. Perfect for first time mums who want the very best for there new born.

- 7" LCD colour screen
- 4 channel, supports 4 cameras for one monitor
- 2way communication

QC-3649 *was $169.00*

$149.00
SAVE $20

Fridge Magnets

Small in size but won't cover up your pictures, notes or shopping lists. These nifty fridge magnets are strong enough to hold up to 10 sheets of paper.

- Pack of 5
- Size: 20(H) x 11(Dia.)mm

LM-1629

$9.95

Note: Paper not included

Bathroom Clock

A convenient and waterproof analogue clock. The suction cup allows you to mount it on to any smooth surface like a tiled wall or mirror. Ideal for renters or the family bathroom.

- Requires 1 x AA battery
- Approx. 130(Dia.)mm

AR-1758

$9.95

BUY 2 for $15 SAVE $4.90

Blue also available AR-1757 $9.95

Never lose your iPhone® 4 Again

The keyring receiver will beep when you become separated from your iPhone® installed in this protective case with built-in wireless transmitter.

- 2m alert range
- USB charging cable included
- Battery life: Up to 58 hours
- Size: 60(H) x 24(W) x 14(D)mm

XC-0364

$39.95

Note: iPhone® and keys not included

For Mums On-The-Go!

Mains Travel Adaptor for iPad®/iPhone®/iPod®

A great travel accessory for Mum! Charge USB powered gadgets, mobile phones and digital cameras. Supplied with USB charge/sync lead and 4 interchangeable plugs.

- Output voltage: 5VDC, 2.1A
- Size: 53(L) x 53(H) x 26(W)mm

MP-3458 *was $29.95*

$19.95
SAVE $10

90W Automatic Car Laptop Power Supply

Automatic power supply for smaller laptops. Simply connect to your car's cigarette lighter socket and select the plug that fits your computer.

- Input voltage: 12VDC
- Power output: 90W
- Output voltages: 15 - 24VDC
- Size: 95(L) x 62(W) x 35(H)mm

MP-3324

Also available: ***150W Car Laptop Power Supply*** MP-3472 $74.95

$59.95

Automatic Liquid Soap Dispenser

Cup hands beneath the nozzle and it automatically dispenses soap. Clean, safe, and germ free.

- Blinking LED indicates operation
- Requires 4 x AA batteries
- Size: 90(W) x 130(D) x 200(H)mm

GH-1187

$14.95

For Mum's iPad® Headrest Mounting Bracket for iPad™

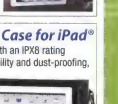
Just mount the bracket to the metal bars on the car seat headrest and place the iPad® into the cradle. Couldn't be easier.

- Size: 244(L) x 188(W) x 15(D)mm

Bracket for iPad™ 1 HS-9010 $14.95

Bracket for iPad™ 2 HS-9011 $14.95

Note: iPad® not included



$14.95 ea

Waterproof Carry Case for iPad®

For the adventurous mum! With an IPX8 rating allowing full water submergibility and dust-proofing, this case is a must have. It's also great for recreational activities such as camping, kayaking, and boating.

- IPX8 waterproof rating
- Dimensions: 320(L) x 214(W) x 2(D)mm

HS-9022

$29.95

Note: iPad® not included

35mm DIGITAL Photo Frame

Holds up to 100 photos which can be downloaded from a MAC® or PC. Unit features an LED torch and comes with a stand and mini USB lead.

- Size: 68(L) x 42(W) x 13(D)mm

XC-0211

$19.95

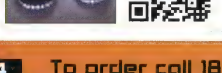
Glow Boots

Makers Name: Robert Willis

Location: New South Wales

"Glowing boots with 9V battery and a strip of LEDs. Stands out in a crowd! White silicone and rubber for waterproofing."

For more details scan the QR code or go to www.jaycar.com.au/makers



For the Sporty Mum! High Performance Stopwatch

This unit will do: 999 laps & splits, fastest, slowest & average lap display. Up to 100 lap times stored in memory. Water resistant to 20m. Complete with lanyard.

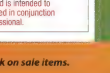
- Pacer function
- Dual timer
- Size: 68(L) x 82(W) x 21(H)mm

XC-0287 *was $24.95*

$19.95
SAVE $5

Automatic Blood Pressure Monitor

A gift for a Mum or Grandma who may need to keep a close eye on her health. Monitors blood pressure and heart rate from the wrist. Requires 4 x AA batteries.



- Uses the oscillometric method
- Arrhythmia detection function (IHB)
- Calculate average measurements
- Stores readings for up to 3 individuals

QM-7254 *was $49.95*

$39.95
SAVE $10

Note: This is not a medical diagnostic device and is intended to provide indicative readings only. It should be used in conjunction with advice from a doctor or other clinical professional.

To order call 1800 022 888

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/05/2013.

HOME LIGHTING

230 Lumens Warm White Candle LED Bulb

LED powered candle bulbs are ideal replacement for chandeliers and other lavish light fittings.

- Long life, low energy consumption

SL-2220

NEW $19.95

200W Mains Dimmer Switch

Suitable for Dimmable LED Bulbs or Incandescent lights.

- Push ON/OFF or rotate to adjust light level
- Operating Voltage: 200-240VAC,1A
- Maximum Power: 200W
- Configuration: Leading Edge or Trailing Edge

PS-4084

NEW $24.95

Mains COB LED Downlights

These high quality GU10 mains voltage LED downlight globes feature a 6W "chip-on-board" (COB) LED module that produces over 500 lumens of brilliant light.

ZD-0625

- 6W, 240VAC

60˚ Cool White ZD-0625 $29.95
60˚ Warm White ZD-0626 $29.95

NEW FROM $29.95 ea

GU10 Mains SMD LED Downlights - 450L

A perfect solution for domestic lighting, shop fittings and many other applications where a stable, bright light and power saving are required.

ZD-0544

- 450 lumens

120˚ Cool White ZD-0544 $19.95
120˚ Warm White ZD-0545 $19.95
60˚ Cool White ZD-0546 $19.95
60˚ Warm White ZD-0547 $19.95

FROM $19.95 ea

Solid LED Strip Lights 12 or 24VDC

An efficient, bright and affordable LED lighting solution. Safe and easy to install. Features wide angle, high brightness SMD LEDs which are powered by either 12VDC or 24VDC. Applications include: under cabinet kitchen, hallway or mood lighting, marine/caravan/motorhome lighting, retail shop fit outs etc.

- Available in 8mm & 11mm widths

Voltage	Colour	Current	Lumens	Dimensions	Cat.	
12VDC	White	200mA	150	500x8mm	ZD-0461	$19.95
12VDC	Warm white	200mA	125	500x8mm	ZD-0463	$19.95
24VDC	White	100mA	150	500x8mm	ZD-0465	$19.95
24VDC	Warm white	100mA	125	500x8mm	ZD-0467	$19.95
12VDC	Warm white	500mA	340	500x11mm	ZD-0550	$34.95
12VDC	White	500mA	390	500x11mm	ZD-0552	$34.95
24VDC	Warm white	200mA	280	500x11mm	ZD-0554	$29.95
24VDC	White	200mA	320	500x11mm	ZD-0556	$29.95

FROM $19.95

240V LED Light Globes

A range of mains LED light globes that are a true replacement for traditional lighting. Offers a brilliant lumen performance with wide, evenly spread light output across a 270˚ output angle, making them better than traditional light globes in many cases.

FROM $14.95

Watts	Lumens	Colour	Type	Cat.	
5W	300	Warm white	Bayonet	SL-2210	$14.95
5W	300	Warm white	Screw	SL-2211	$14.95
5W	360	Natural white	Bayonet	SL-2212	$14.95
5W	360	Natural white	Screw	SL-2213	$14.95
10W	820	Warm white	Bayonet	SL-2214	$29.95
10W	820	Warm white	Screw	SL-2215	$29.95
10W	900	Natural white	Bayonet	SL-2216	$29.95
10W	900	Natural white	Screw	SL-2217	$29.95

SL-2210 SL-2213 SL-2216

GU10 LED Downlight 3 x CREE® 2W

ST-3896

Mains powered and dimmable with no additional power supplies, transformers or ballasts required. Each assembly includes a junction box and spring clips to mount to any surface up to 25mm thick. Cut out 90mm.

FROM $39.95

ST-3896	Cool White	Ea	45˚ Lumens	$39.95
ST-3897	Warm White	Ea	35˚ Lumens	$39.95
ST-3898	Cool White	Pk4	45˚ Lumens	$149.00
ST-3899	Warm White	Pk4	35˚ Lumens	$149.00

Mains Wireless Power Monitor

With the sensor unit installed in the fuse box, household power usage data is wirelessly transmitted to the indoor display unit up to 50m away.

- Electricity usage (watts), cost and time displayed
- Suitable for single phase only
- Batteries included
- Display size: 101(H) x 80(W) x 42(D)mm
- Sensor size: 75(L) x 60(W) x 35(H)mm

MS-6160 ***was $79.95***

$69.95 SAVE $10

Smart Powerboard with Energy Meter

6 way smart powerboard with digital energy power board. One socket never switches off and one "smart" outlet can be used for your main item such as your computer. When you switch off your computer it will then switch off your related items eg: printer, scanner. LCD display also shows energy consumption.

- Surge protection, overload, spike and noise filtering
- Energy meter with CO_2
- Size: 385(L) x 60(W) x 30(D)mm

MS-6152 ***was $49.95***

$39.95 SAVE $10

Energy Efficient Ecolume 9W Downlight Kit

Consumes only 9W of power whilst producing almost 700 lumens of light thanks to the four Philips-Lumileds Luxeon Rebel ES LEDs. Kit supplied with dimmable LED driver with leading and trailing edge dimming.

Warm White ZD-0355
was $79.95 now $69.95
save $10.00
Cool White ZD-0357
was $79.95 now $69.95
save $10.00

$69.95 SAVE $10

Dimmable Constant Current LED Driver

A compact mains powered unit, capable of driving 1-4 high power LEDs at a constant current of 700mA (10W max), whilst also being dimmable, it is also an excellent driver for domestic LED lighting projects or as a replacement for a failed LED driver. See website for specs.

- Overload and short circuit protection
- Dimmable with leading edge or trailing edge triac dimmer
- Size: 112(L) x 39(W) x 25(H)mm

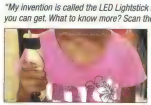
MP-3365 ***was $29.95***

$19.95 SAVE $10

LED Lightstick

Makers Name: Len Neale ***Location: Queensland***

"My invention is called the LED Lightstick and it's as simple as you can get. What to know more? Scan the QR Code..."



For more details scan the QR code or go to www.jaycar.com.au/makers

OUT AND ABOUT

1kW Sinewave Inverter Generator

Ideal for camping or at home during power blackouts. This generator produces a stable pure sine wave 230VAC to power most domestic appliances including sensitive electronics. Features include low noise level, low oil cut-out, and overload circuit breaker. See website for full features and specifications.

- Weight:13kg
- Size: 470(L) x 400(H) x 255(W)mm

MG-4501

$599.00

Indoor Photocatalyst Mosquito Traps

Through a photo catalytic reaction, carbon dioxide will be emitted which will attract mosquitos and other flying insects. The fan will bring them in and dries them until they die. They also act as air purifiers. Two models available:

Indoor

- Size: 170(L) x 115(Dia.)mm

YS-5514

NEW $29.95

Indoor/Outdoor

- Size: 248(H) x 245(Dia.)mm

YS-5516

NEW $49.95

Mains Power Adaptor with RCD

Convert your 15A power lead to fit a 10A power outlet whilst adding the additional safety of RCD earth leakage protection. Features a 10A circuit breaker/RCD in case you accidentally overload the device.

- Voltage: 240VAC, 50Hz
- Size: 180(H) x 135(D) x 124(W)mm

MS-4044

NEW $79.95

12V LED Spot/Running Lamps

Super bright running lamps produce enough light to run during the day time or used as a spot/flood light fixture. The two piece set produces 120 lumens, improving visibility of vehicles on and off the road.

$39.95 Pair

- 9 White LEDs
- Waterproof, long life and easily installed
- Size: 88(Dia.)mm

SL-3445

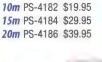
Limited Stock

15A Extension Leads

Heavy duty mains extension leads with 15A plugs and sockets, and a thick orange flexible cord. Perfect for caravans and motorhomes.

10m PS-4182 $19.95
15m PS-4184 $29.95
20m PS-4186 $39.95

PS-4182



FROM $19.95

3 LED Torch with AM/FM Radio

An extremely handy rechargeable torch for your next camping trip. Features 3 bright white LEDs, an AM/FM radio, as well as a personal alarm in case of emergency.

- Includes 1 x USB MicroB, 1 x USB MiniB, 1 x Nokia Plug adaptors
- Size: 136(L) x 48(W) x 34(H)mm

ST-3357

NEW $29.95

Rider Must Haves!

Bluetooth® Motorcycle Headset

Communicate wirelessly whilst riding your motorcycle. It enables you to pair two devices simultaneously, such as two mobile phones, or a mobile phone and another AR-1864, giving you an intercom between rider and pillion. IPX6 certified for use in all weather conditions.

- Large buttons
- GPS support and velcro pieces included

AR-1864

$79.00

Bike Head Torch

Providing up to 700 lumens of intense white light, this head torch is the ideal safety addition for any cyclist. Mains charger included.

- Includes handle bar bracket
- Modes: High, low, flashing
- Burn time: 20hrs on low brightness
- Size: 60(L) x 46(Dia.)mm

ST-3464

NEW $99.00

4 LED Marine Strobe Light

Ideal for marine use to ensure your vessel stays visible at night or in poor light. Features a light sensor so it stays on night and auto-switches off during the day.

- Requires 2 x D batteries
- Size: 230(H) x 52(Dia)mm

ST-3232

NEW $34.95

Electric Bike Mobile Office Maker Project

"I've always had the idea of riding my bike and work at the same time. I thought of putting a bike together that I can use as a car replacement, and also use as a mobile office. The electric bike has approx 150km before needing a recharge. I can go anywhere in Melbourne without the need of using a car. A special water bottle has a built-in battery pack and can keep my cell phone and iPad® charged for unlimited time using solar energy. The solar panel is easily removable from the bike and can be used at coffee shops to charge devices. I mounted some speakers with audio amplifier to listen some music and take phone calls while on the move."

For more details scan the QR code or go to www.jaycar.com.au/makers

Gooseneck Windscreen/ Cigarette Lighter GPS Mount

Plugs into a cigarette lighter socket and adjusts to fit a GPS or mobile phone. It also has a piggyback socket so it can use the outlet to power the device. Suction glass mount also included.

- Size: Base diameter: 67mm, Gooseneck: 180mm long

HS-9002

Note: Smartphone not included

$24.95

In-Car FM Transmitter for iPhone®/iPod®/iPad® with Charger

Simply connect the transmitter to your iPhone®, iPod® or iPad® select a frequency from 88.1 to 107.9MHz then tune in using your FM car radio. It also has a built-in mic for hands-free communication and a USB port built into the cigarette lighter plug for charging other popular electronic devices.

- Working voltage: 5VDC
- LCD display
- Size: 100(L) x 30(W) x 12(D)mm

AR-3124

$29.95

To order call 1800 022 888

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/05/2013.

ACCESSORISE YOUR HOME THEATRE

Shielded Full Range Speakers

Suitable for use in surround speakers in home theatre system, computer multimedia speakers and portable speaker designs. See website for full specifications, frequency curves and technical drawings.

- 4 x screw mounting holes

Shielded 1" 1W 8-Ohm
- Size: 36(Dia.) x 13(D)mm

AS-3030 $8.95

Shielded 2" 10W 8-Ohm
- Size: 53(Dia.) x 30(D)mm

AS-3032 $14.95

Shielded 3" 15W 8-Ohm
- Size: 90(Dia.) x 53(D)mm

AS-3034 $19.95

NEW FROM $8.95 ea

Stereo Amplifier

2 x 200WRMS Channel stereo amplifier with remote control. Higher power and more features in a standard Hi-Fi component size.

- inputs (Analogue): DVD/CD, Aux 1&2, Phono, Tap, USB
- Size: 430(W) x 241(D) x 114(H)mm

AA-0484

$329.00

Fibre Optic Audio Leads

A range of fibre optic TOSLINK cables with superb build quality. Suitable for achieving excellent audio reproduction in home cinemas that support Dolby Digital 5.1 (AC-3) surround sound, DTS, and more.

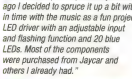
1m WQ-7301 $14.95
3m WQ-7302 $24.95
5m WQ-7303 $39.95

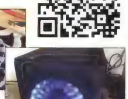
NEW FROM $14.95

Party Speaker Maker Project

Makers Name: James Anderson

"I have a computer speaker system and a couple of years ago I decided to spruce it up a bit with some LEDs that flash in time with the music as a fun project. I used a LM3915N LED driver with an adjustable input and flashing function and 20 blue LEDs. Most of the components were purchased from Jaycar and others I already had."





For more details scan the QR code or go to www.jaycar.com.au/makers

6-in-1 USB Universal Remote Control

Manage a database of IR codes on the computer, not from the remote control. Use the provided software for easy setup or to individually assign a function to each button. Regular updates to the database ensure compatibility with the latest TVs, DVD players, etc.

- Advanced learning functions
- Up to 4 macro buttons
- Requires 3 x AAA batteries (not included)
- Compatible with Windows 2000/XP/Vista/7
- Size: 190(H) x 48(W) x 20(D)mm

AR-1719

Due Early May

NEW $29.95

Audio/Video Selector Switch

Connect up to 4 AV sources to one television and switch between them remotely. Features 4 x RCA composite/ S-Video inputs and 1 x RCA composite/S-Video output.

- Size: 190(L) x 115(W) x 50(H)mm

AC-1654

NEW $44.95

Boost your TV Reception!

Indoor Digital TV Amplifier

A portable and compact amplifier capable of boosting signals to indoor TV antennas for both digital and analogue signals. It can be powered from mains or USB (mini plug available separately) and features manual UHF/VHF gain adjustors to give you greater control over your signal. Standard PAL connections.

- VHF Frequency: 45 - 230MHz
- UHF Frequency: 470 - 862MHz
- Size: 100(L) x 60(W) x 27(H)mm

LT-3281

NEW $24.95

TV Signal Strength Meter

Take the stress out of installing your digital TV antenna. Connect this meter and adjust the angle of your antenna until the LED indicator shows you've hit the right spot. Adaptors included.

- Requires 1 x 9V battery

LT-3332

$39.95

Watch Pay TV All Over The House

Uses cutting-edge design in wireless DIGITAL technology to send stereo audio and video interference free around the home. Also integrates an infrared extender which allows control of the settings from the receivers end. Supplied with power adaptors.

- 2.4 GHz band
- IR range 30 to 57kHz
- Transmits up to 100m
- Size: 170(W) x 130(D) x 43(H)mm

AR-1872 ***was $169.00***

$139.00 SAVE $30

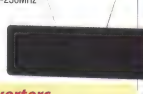
Indoor Flat Panel Antenna with Amplifier

Capable of picking UHF and VHF signals as well as DAB+ radio signals. Features 2 adjustable antennas and a standard PAL adaptor as well as a separate amplifier which may be required for areas with weaker indoor reception.

- VHF Frequency: 45-230MHz
- UHF Frequency: 470 - 862MHz
- Panel size: 480(L) x 109(W) x 54(D)mm

LT-3156

NEW $39.95



Audio Converters

HDMI Audio Extractor

No need to throw out your old audio system. Just use this device to extract the audio signal from your HDMI source (like a Blu-Ray player) and redirect it for use via an SPDIF TOSLINK optical cable, SPDIF RCA cable, or a 3.5mm to 2 x RCA cable for output to an amplifier or home theatre audio system.

- Size: 70(L) x 60(W) x 20(H)mm

AC-1637

NEW $99.00

Digital TOSLINK/ Coax Audio Converter

Accepts S/PDIF audio input from either the coax or TOSLINK cable and will then output to the coax and TOSLINK ports on the opposite side. With its built-in amplification feature, it can also serve as a repeater of audio signals and extend (double) the transferring distance.

- Size: 46(W) x 46(D) x 24(H)mm

AC-1601

$59.95

Bluetooth® Headsets

Bluetooth® Stereo Headset

Easily paired with any Bluetooth® device such as a mobile phone or computer. Extremely light and comfortable.

- Microphone for Bluetooth® hands-free capability.
- Lithium-ion rechargeable batteries provide hours of use.
- USB charging cable included.

AA-2067 ***was $49.95***

$44.95 SAVE $5

Hi-Fi Stereo Bluetooth® Headset

Listen to MP3 music from a mobile phone or a PC without any cables. Features a full cup leatherette headset and rechargeable Li-Po battery. Perfect for the commuter, student, or multi-tasker.

- Allows 2 devices to be connected simultaneously
- Supports A2DP, AVRCP, headset, hands free profile
- Low battery LED and audio indication
- Working range: up to 10m

AA-2082 ***was $69.95***

$59.95 SAVE $10

Jaycar Electronics — ARDUINO COMPATIBLE PRODUCTS

Better, More Technical!

LeoStick (Arduino Compatible)

A tiny Arduino-compatible board that's so small you can plug it straight into your USB port without requiring a cable! Features a full range of analogue and digital I/O, a user-controllable RGB LED on the board and an on-board Piezo/sound generator.

- ATmega32u4 MCU with 2.5K RAM and 32K Flash
- 6 analogue inputs (10-bit ADC) with digital I/O, 14 extra digital I/O pins

XC-4266

$29.95

LeoStick Prototyping Shield

Add your own custom parts to the LeoStick to build projects or add more I/O connectors. Fits on the top of the LeoStick and provides you a free matrix of plated-through holes for your own use.

- 64 general-purpose plated holes for your parts
- Includes male header pins
- Gold-plated surface

XC-4268

$7.95

Mini Servo 4.8V-6V

Mini sized servo perfect for R/C or robotics applications where size is at a premium.

- Weight: 26g
- Size: 35(l) x 16.9(W) x 32(H)mm

YM-2760

$17.95

Arduino Based Tank Maker Project

Makers Name: Jim Clark · Location: Victoria

"The "Arduino Starter Kit" got me started working with servos and a range of sensors. The Robot Tank Chassis is a perfect match with the Arduino Motor Shield to create a basic Rover type device. Then I wanted to build in some intelligence to avoid obstacles. "

For more details scan the QR code or go to www.jaycar.com.au/makers

EtherMega, Mega sized Arduino 2560 Compatible with Ethernet

The ultimate network-connected Arduino-compatible board: combining an ATmega2560 MCU, onboard Ethernet, a USB-serial converter, a microSD card slot for storing gigabytes of web server content or data, Power-over-Ethernet support, and even an onboard switchmode voltage regulator so it can run on up to 28VDC without overheating.

- 10/100base-T Ethernet built in
- 54 digital I/O lines
- 16 analog inputs
- Prototyping area

XC-4256

$119.00

USBDroid, Arduino-compatible with USB-host Support

This special Arduino-compatible board supports the Android™ Open Accessory Development Kit, which is Google's official platform for designing Android™ accessories. Plugs straight into your Android™ device and communicates with it via USB. Includes a built-in phone charger.

- USB host controller chip
- Phone charging circuit built in
- 8 analog inputs
- microSD memory card slot

XC-4222

$69.95

"Eleven" Arduino-compatible Development Board

An incredibly versatile programmable board for creating projects. Easily programmed using the free Arduino IDE development environment, and can be connected into your project using a variety of analog and digital inputs and outputs. Accepts expansion shields and can be interfaced with our wide range of sensor, actuator, light, and sound modules.

- 8 analog inputs

XC-4210

$39.95

Mega Prototyping Shield

Fits the EtherMega (XC-4256) and Arduino compatible "Mega" size boards so you can fit your own parts for projects. Includes header pin sets.

- Over 300 general-purpose plated holes for your parts
- Handy 5V and GND rails
- All Arduino I/O header pins branched out for your use
- Gold-plated surface
- Reset button

XC-4257

$17.95

Arduino Experimenters Kit

Learn about the exciting new world of Arduino with these easy to build projects. From flashing an LED to moving things with a servo. Complete with instructions and a supporting web page and software examples.

- No soldering required

XC-4262

$89.95

For ARDUINO video and projects visit www.jaycar.com.au/arduino

ProtoShield Basic

A prototyping shield for the Eleven (XC-4210) and USBDroid (XC-4222). Provides plenty of space to add parts to suit any project, keeping everything neat and self-contained. Includes dedicated space to fit a power LED and supply decoupling capacitor.

- Gold-plated surface

XC-4214

$4.45

YOUR LOCAL JAYCAR STORE – Free Call Orders: 1800 022 888

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Tweed Heads (NET JUNCTIONS)	Ph (07) 5524 6566
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Warners Bay NEW	Ph (02) 4954 8100
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Mermaid Beach	Ph (07) 5526 6722
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Reynella	Ph (08) 8387 3847

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Geelong	Ph (03) 5221 5800
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Kew East	Ph (03) 9859 6188
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Springvale	Ph (03) 9547 1022
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CLASSiC DAC Pt.4

Final article gives the test procedure and describes how it's used

By NICHOLAS VINEN

Having described how the new high-performance CLASSiC DAC works and shown how to build it, it's now time to set it up & put it through its paces. We'll also go into some details about how to use it, especially the more advanced features.

We left off last month having assembled the CLASSiC DAC PCBs and connected them together in the case. Before firing it up, you will need to program the microcontroller, if it wasn't supplied programmed.

Before doing that, it's a good idea to do some quick checks to ensure that the power supply is working and delivering the correct voltages. This will avoid damaging the ICs when power is applied to the rest of the circuit.

Test procedure

Before applying power, check that:

- IC4 and IC6 are out of their sockets;
- JP1 is not fitted;
- JP2 and JP3 are fitted in the 0dB positions;
- VR1, VR2 and VR3 are rotated fully anti-clockwise;
- LK1 and LK2 (closely-spaced pairs of pads labelled in red on the overlay diagram) are clear of solder;
- All the DIP switches are off;
- Your DMM is set to measure DC volts; and
- You have the PCB orientated as shown in the overlay diagram last month, with the connectors at left, so that you can easily follow the instructions below

With a DMM at the ready, connect a 9VAC plugpack and switch it on, then measure the output of REG3 (bottom-most pin) using its tab mounting screw as the ground reference point. You should get a reading of around 5V (4.8-5.2V). If not, switch off and check for faults.

Also measure the output of REG5, the 4-pin SMD to the left of bobbin inductor L6; use the same ground reference point as before and carefully probe its top-most pin. You should get a reading very close to 3.3V. If this is not between 3.2V and 3.4V, switch off and check the board carefully, especially in the power supply (lower left) area.

Assuming it's OK so far, check the ±15V outputs from REG1 and REG2. Like REG3, their outputs are the bottom-most pin and for REG1, this should read around 15V (14.5-15.5V say). **When checking REG2, be aware that you can't use its mounting screw as a ground reference since that is actually connected to the regulator input.** You should get a negative voltage in a similar range as that indicated for REG1.

Finally, check the input to REG5, ie, its bottom-most pin (we measured its 3.3V output earlier). You should get a reading just below 4V. If it's much higher than that, it could be that REG4 is not operating correctly and this would lead to REG5 overheating during operation so switch off and check for faults around REG4. If you get the correct reading, switch off anyway as the power supply tests are finished.

At this point we should say that when we ran through these tests for

Setting Up The Remote Control

A universal remote control can be used to control the DAC and is virtually mandatory if you will be using the SD card playback capability. Before the remote can be used, it must be set to send out the right codes.

For the Altronics/Dynalink A1012 remote, put it in TV mode and use code 156. To do this, press "TV" while holding down the "Set" button, then enter 156 on the keypad. If this conflicts with other equipment you own, slide DIP switch #3 on the PCB to its ON position, then set the remote to TV code 170 instead.

For the Jaycar/Digitech AR-1726 remote, use code 252. To enter this code, hold down the mode button you want to assign (TV, VCR, AUX, etc – it doesn't matter which) for a few seconds. Then enter the code, 252, press OK and after a couple of seconds, press the mode button again.

If for some reason this doesn't work for you and you want an alternative, change the position of DIP switch #3 to ON and use code 281.

Verify that the remote is working by changing inputs with the numeric buttons 1-8. You should also be able to turn the DAC on and off (into/out of standby mode) using the power button and change the volume using the volume up/down buttons. The power switch LED will flash to acknowledge the reception of infrared commands.

The unit will work with most universal remotes including the Altronics A1012.

our prototypes, in two cases the 7915's (REG2) output was much higher than expected at around -20V. This was fixed by replacing the regulator with an On Semiconductor branded unit which we got at our local parts shop.

We think that the batch of 7915s we had in stock were dodgy but it's possible that this is a widespread problem with certain brands of regulator under these conditions (input voltage close to maximum, output current draw low). While the -20V would probably have dropped quickly once a load was applied, rather than risk damage to the op amps, we elected to replace the regulator and suggest you do the same if this happens to you.

Making repairs

If you do have to de-solder a component to replace it, be careful as the plated-through holes really hold onto the pins well and you don't want to damage the PCB.

For TO-220 package parts like REG2, the best method is to remove the screw, bend the tab up to vertical, hold the tab with pliers and heat all three pads simultaneously (add solder if necessary) while gently pulling the part away from the board. If it doesn't come out a few seconds after all the solder has melted, wiggle the tab from side-to-side. If it still won't come out, let it cool down and try again later, to avoid lifting any pads from excessive heat application.

Smaller components can be removed using a similar technique although it's usually easier to cut one or more of the leads off first, remove the body of the component and then de-solder the leads individually. A solder sucker can then be used to clear the holes so that a new component can be fitted.

Next steps

Now short both LK1 and LK2 with solder. Be careful not to touch any adjacent components with the soldering iron. You may have to try a few times before you manage to successfully bridge the pads since they are quite small.

Use a DMM to check that there is continuity between the output pin of REG3 (bottom) and the lower pin of JP1. Check also for continuity between the top-most pin of REG5 and the upper pin of JP1.

Now plug IC4 and IC6 into their sockets, checking the required orientation carefully (they're different). If you haven't already connected the main board to the front panel with the two cables made earlier, do so now. Slide the top-most DIP switch (Power On) to the On position and fit a shunt on JP1 in the appropriate position. Most TOSLINK receivers will operate from 3.3V these days but it's best to check with the supplier if unsure.

Programming the micro

If you built the DAC from a kit or are using one of our pre-programmed microcontrollers, it should be ready to go. If not, you will need to plug a pin header into CON11's pads on the PCB; it should be a tight fit and will be held in by friction. Connect a PICkit3 or similar in-circuit programmer and flash IC5. The HEX file is available from the SILICON CHIP website.

You can use the PICkit3 to supply 3.3V for the microcontroller while flashing. We have confirmed that this works OK. But if that isn't possible for some reason, you can connect the plugpack instead.

Once MPLAB is configured for the correct device (dsPIC33FJ128GP306), the ICSP is connected and power is applied. The chip should then be recognised and its revision number shown. If not, switch off and check for faults, especially in IC5's solder joints.

You may also find, as we did on one of our prototypes, that the friction-fit header makes marginal contact and you have to put pressure on it to get a reliable connection. In this case you can simply solder the ICSP header (CON11) to the PCB.

Once the chip has been programmed, you should get a message that it was successfully verified. You can then switch off, disconnect the programmer and unplug CON11, assuming you haven't soldered the latter in place.

Checking the LEDs

With power applied, confirm that the power LED and the Input 1 LED light up. A brief press of the power button should cycle through the available inputs and let you check that all eight input LEDs are working OK and have a reasonably similar brightness level.

Because we're running the blue LEDs at a low current (to avoid frying your eyeballs in a dimly lit room), you may find that there are some "duds". We had a few of these in the batch of

LEDs we bought and ended up replacing several on the PCB. If you measure the resistance between anode and cathode, you will probably find any duds will measure below 1kΩ in one or both directions. This shunt resistance is a manufacturing fault; the LEDs probably work OK at higher currents so you can use them for something else.

Even if you don't have any duds, the LED brightness might be uneven. We have tried to compensate for the different efficiency of green, blue, yellow and red LEDs by varying the current limiting resistors but your LEDs may have a different brightness/efficiency than ours.

This won't usually matter but if they vary wildly, you may want to shunt some of the limiting resistors or possibly even replace them to get a more even display; not that it's all that critical as they are normally only lit up one at a time.

Setting quiescent current & gain

Now set up the headphone amplifier. Measure the voltage across the top-most 22Ω emitter resistor in the upper-right corner of the board, next to ZD7. There are a pair of adjacent pads connected in parallel with this resistor that you can use to connect the probes.

You should get a very low reading, ie, just a few millivolts. Now slowly turn VR2 clockwise until you get a reading of 0.1V. This should be with VR2 rotated roughly half-way through its full travel. Then measure the voltage across one of the other 22Ω resistors immediately behind the headphone jack socket and adjust VR3 to get the same reading.

If you are planning to use high impedance headphones (>60Ω) then you will probably want to set the headphone output gain to +12dB. To do this, move JP2 and JP3 to their alternative positions.

Final testing & set-up

The final test is to check that the sound output is working correctly. This is done most easily with a WAV file loaded on an SD card although there are other methods (see below).

Load a WAV file copied from a CD (ie, 44.1kHz 16-bit stereo) onto a blank SD card and plug it in to the DAC. Connect headphones (using a 3.5mm to 6.5mm adaptor if necessary) and turn the volume down close to minimum. If you don't have headphones, you can hook up an amplifier to the line outputs instead.

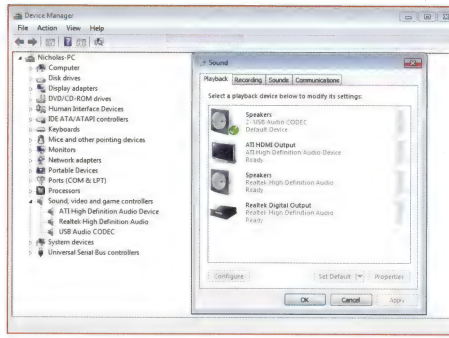


Fig.14: when the DAC is connected to a computer's USB port, it will be detected regardless of whether the DAC itself has power. This shows how it appears in Device Manager under Windows 7 – as "USB Audio CODEC" under "Sound, video and game controllers". You can check that it is the default output device in the Sound control panel and if not, make it the default.

Power up and check that LED8 (red) turns on, dimly at first and then brighter once the SD card has been initialised. If you now slowly turn up the volume, you should hear the file being played back. Check that it is in stereo and distortion-free.

If LED8 doesn't light or stays dim, check the soldering on the SD card socket and the microcontroller. It could also be a problem with the components behind the SD card socket.

There's also a possibility that the WAV file format is incorrect; while the DAC will play most WAV files with a supported sampling rate, bit depth and number of channels, the WAV format allows for quite a bit of variation and some files may not be properly recognised. So it might help to reformat the SD card and load a different WAV file on.

If that went well, it shows that a large portion of the circuit is working correctly. If you can't get the file to play from the SD card though, or you don't have a suitable card, try one of the following methods to help narrow down the problem.

Testing the USB interface

Power down the DAC and plug it into a computer using an appropriate cable (Type A to Type B). It should be recognised and a new audio interface should appear (the DAC's USB interface runs off the computer's power supply). Fig.14 shows how the device shows up in Windows 7 Device Manager (as "USB Audio CODEC") and in the Sound settings in the Control Panel.

In most cases, your computer will automatically select the USB audio device as the currently active sound output. If it doesn't, you will then have to make it the current output device. Once you've verified that it is active, switch the DAC power on and play some audio from the computer. It should sound clear and undistorted.

If the SD card output works but USB audio doesn't, check the circuitry around IC2. The most likely symptom if there is a fault in this circuitry is that the USB Audio CODEC will not be detected by your computer. Alternatively, if USB audio works but playback from the SD card doesn't, this suggests either the DAC doesn't recognise the file format or there is a problem in the circuitry associated with the SD card.

Testing the other inputs

Finally, if you have a TOSLINK or S/PDIF digital audio source, check

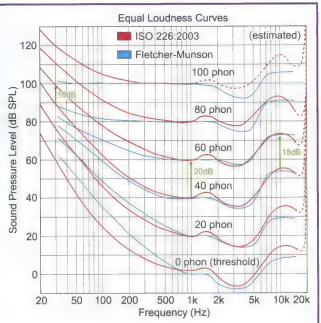


Fig.15: each red line plots the sound pressure level required to give sounds that appear to have equal loudness over the range of audible frequencies, from 20Hz up to nearly 20kHz. The lines are plotted for 0, 20, 40, 60, 80 and 100 phon where 1 phon = 1 dB SPL at 1kHz. The auto-loudness feature compensates for the ear's loss in sensitivity at low frequencies by progressively boosting the bass as the volume level is reduced (see text).

that the other inputs are working correctly. The associated input LED should light up dimly when a signal source is plugged into each input and you can then use brief presses of the power button to cycle the current input until the one being tested is selected. You can then check that the audio output is clean.

Having tested that all the inputs are working (or at least, those which you can) and that the headphone output is OK, that verifies that virtually all the circuit is operating correctly.

Setting the DIP switches

The "Setting Up The Remote Control" panel (page 58) discusses the use of DIP switch #3 to select the alternative set of remote control commands. DIP switch #1 determines whether the unit switches on initially when power is applied; if set to off, the DAC will start up in standby mode and must be switched on before use by pressing the power button on the unit itself or on the remote control.

If the second DIP switch is left off, the unit will only change inputs automatically when an SD card is inserted or when the unit is plugged into a computer via USB. In both these cases, it automatically switches to the relevant input. With DIP switch #2 on, however, it will also switch to another input if a valid signal appears on that input and either there is no signal on the current input or there has been no audio on the current input for at least 10 seconds (this time period can be changed via the configuration file; see below).

Finally, the fourth DIP switch controls whether the power LED is lit dimly when the unit is in standby (on) or not lit at all (off).

Using the DAC

At this stage, if you just want to use the unit as a plain DAC, you should be ready to go. When on, it can be switched into standby by holding the power button down for a second or so, or by pressing the on/off button on the remote control. A brief press of the power button switches it back on. The current input can be changed by further presses on the power button or via the numeric buttons 1-8 on the remote control.

The mute button on the remote control can be used to temporarily mute the output while the volume buttons will change the volume digitally. However for best quality, leave the digital volume at or near maximum and adjust the volume on the headphone volume pot or, when using an external amplifier, with that amplifier's volume control.

Most of the remaining controls are useful mainly when playing back WAV files from an SD card, ie, when using the CLASSiC DAC as a music or audio player.

SD card playback

If you have more than a few audio files on an SD card, then typically these should be arranged in folders (aka directories). For example, if playing music, you could have one folder for each musician, with another set of folders within these for each album or disc. The WAV files would then be within these folders.

Alternatively, you could simply have one folder in the root directory for each disc, with its name prefixed by the artist/performer. Both schemes will give a similar result.

If you want the tracks to play back in the same order as they are on the CD then the usual practice is to prefix each track with its number, padded out to two digits. For example, the first could be named "01 – Track One.wav" or "01 Track One.wav". That way, when sorting the file names alphabetically (which is the default), they will be played in the correct order.

With a card inserted, use the left and right arrows on the remote control to skip between tracks within a folder. Skipping past the beginning or end will initiate playback from the previous/next folder. Similarly, if you press the left arrow when playing the first track of the first folder it will "wrap around" to play the last track of the last folder. Conversely, if you press the right arrow on this last track, it will wrap in the other direction.

The down arrow will skip to the first file in the next folder regardless of which track is being played from the current folder and similarly, the up arrow will go to the first file in the previous folder. This is roughly equivalent to "next/previous disc" with a CD changer.

So with either of the folder schemes mentioned above, the up and down arrows will move between the discs from a given artist or performer and if you continue pressing these keys, you will switch to the (alphabetically) next/previous artist.

Navigating the tracks

While there's no display to show you which track is currently being played (ie, you're navigating "blind"), if you have a list of the folders on the card then it is usually a fairly simple matter to navigate to the one that you wish to use.

For reference, a 16GB SD card will fit around 23 full CDs worth of WAV files, a 32GB card 45 CDs and a 64GB card at least 91 CDs worth. In practice

you will fit more since CDs are rarely full (ie, the track total is usually less than 80 minutes).

Changing file order

It's also possible to play tracks from the card in a different order. If you press the "OK" button on the remote then the playback order changes from alphabetically sorted to shuffled. Then when you change to the next/previous track, it will jump to a random track in the current folder.

The order of folders is also shuffled, so pressing the up/down arrows will go to a random folder within the current nesting level.

Pressing the OK button again then changes the playback order so that the tracks play in the order that they are stored on the SD card. This will tend to be the order in which you loaded the folders and files onto it, although that isn't guaranteed. A third press of the OK button returns to the original alphabetical sort.

Tone controls

The digital tone controls (bass/treble boost/cut) operate only when playing back WAV files from an SD card. This is because we wanted to avoid having audio pass through the microcontroller if it wasn't necessary, as the sound quality could potentially be affected even though it is digitally transmitted (eg, due to added jitter). However, since the microcontroller is in charge of WAV playback anyway, we have taken advantage of the ability to do some extra processing.

Table 1: Remote Control Buttons With Same Function In All Modes

Button	Function
Power	Enter/leave standby
Mute	Turn mute on or off
1-8	Switch to input 1-8
Pause	(WAV) Pause/resume
Rewind/Fast forward	(WAV) Skip back/forward 10 seconds
Play/Stop	(WAV) Start/stop playback
TV/Video (A1012) / Menu (AR1726)	Go to control mode 1 (normal)
Teletext (A1012) / TV/VCR (AR1726)	Go to control mode 2 (tone controls)
Page hold (A1012) / TV/AV (AR1726)	Go to control mode 3 (crossfeed control)

This feature is limited to sampling rates of 48kHz and below because the microcontroller simply isn't fast enough to play back higher sampling rate WAV files and process them too. It's automatically disabled at higher sampling rates.

You can boost or cut the treble or bass by a few decibels. Since this is done digitally, it has relatively little impact on sound quality although there is inevitably some loss in dynamic range.

By default, the bass boost/cut is affected with a first-order low-pass filter that has a corner frequency of 500Hz. Similarly, treble boost/cut uses a first-order high-pass filter with a -3dB point of 2kHz. You can adjust these frequencies within a limited range although there's little benefit in doing so. Briefly, to use the tone controls:

- Press the "teletext"* (A1012) or TV/VCR (AR1726) button to enter control mode 2 (* = see Table 1).
- Press the record button to enable the tone controls.
- Use the up/down/left/right buttons to adjust treble and bass levels. Note that with the AR1726 remote, these may not automatically repeat when held down.
- If necessary, use the volume up/down and channel up/down buttons to adjust the corner frequencies.
- Press the TV/Video (A1012) or Menu (AR1726) button to switch the remote functions back to default.

Note that as you adjust the tone controls, the volume automatically changes to avoid clipping the audio signal. This interferes with the ability to compare the sound with and without tone controls so you can press the 0 (zero) button while in control mode 2 to reduce the audio volume

Digital Tone Control Implementation

As described in the main text, the CLASSiC DAC can provide digital tone controls when playing back WAV files. This involves manipulating the digital audio data after it has been read off the SD card and before it is send out as an S/PDIF stream to eventually reach the DAC IC.

To do this, we are using a digital signal processing (DSP) technique known as an Infinite Impulse Response (IIR) filter. This is effectively a digital version of the analog RC low-pass/high-pass filter although IIR can also be used to build the digital equivalent of more complex filters too.

The name "infinite impulse response" comes from the fact that with an IIR filter of sufficient precision, a transient (impulse) will have an exponentially decaying effect on the output of the filter that never quite ends although practical limits of numeric precision mean that its influence will eventually reach zero. This is as opposed to Finite Impulse Response (FIR) filters which have a defined "window" so each impulse only affects a limited number of audio samples before/after that impulse.

The only numerically intensive part of implementing an IIR filter is calculating the filter coefficients, which can be done once for a given combination of corner frequency, sampling rate and gain. The CLASSiC DAC firmware does these calculations using floating point arithmetic. This is slow but because it's only done when the filter or sampling rate changes, that doesn't matter.

During playback, each IIR filter only requires a few integer multiplication operations (2-3) and a summation per audio sample.

For more information on how to build a simple digital IIR filter, see the following page: **http://freeverb3.sourceforge.net/iir_filter.shtml**

The low-pass filter in the crossfeed routine also uses an IIR algorithm but this is combined with a small delay buffer in order to create the desired effect.

Table 2: Mode-Specific Remote Control Buttons

Button	Function in Control Mode 1	Function in Control Mode 2	Function in Control Mode 3
ChUp/ChDn	Pan left/right	Change bass -3dB frequency	Change crossfeed attenuation
VolUp/VolDn	Change volume	Change treble -3dB frequency	Change volume
Left/right arrow	Previous/next WAV file	Change treble gain	Change crossfeed LPF frequency
Up/down arrow	Previous/next WAV folder	Change bass gain	Change crossfeed delay
OK	Change playback order	Reset tone controls	Reset crossfeed settings
Record	Pan to centre	Toggle enable tone controls	Toggle enable crossfeed
0	-	Tone control equal volume mode	-
9	-	Enable auto-loudness	-

regardless of the tone control settings. You can then use the record button to toggle the tone controls on and off for an A/B comparison.

Note that you will probably need to increase the headphone/amplifier volume in this mode. Pressing zero again toggles it off (and increases the volume again), which you should do when you're finished as this gives better audio quality.

Auto-loudness

You may have noticed that music normally sounds better when it's loud. It's because the human ear's frequency response is different at different sound levels. As you lower the volume of the music, keeping its frequency distribution even, the bass (and to a lesser extent, the treble) seem to "drop out". The result is that the music sounds "thin" at lower volume levels.

To see why this is, have a look at the accompanying graph, Fig.15. This shows both the original equal-loudness curves ("Fletcher-Munson") and the more up-to-date and accurate ISO 226-2003 curves (reproduced from Wikipedia).

Consider the red line showing the 60 phon level (a measure of apparent loudness). At 1kHz, the sound level must drop 20dB for an apparent reduction in loudness of 20 phon. But if you follow the red 60 phon line down to 30Hz, the drop to the 40 phon level is just 10dB (from 100dB SPL to 90dB SPL).

Hence a drop of 20dB at 30Hz reduces the apparent sound level by about 40dB. By boosting bass at lower volumes, we can compensate for this.

The CLASSiC DAC's auto-loudness feature does just this; it also boosts treble at low volumes but less so than bass. Some old amplifiers had this type of feature (in analog, naturally) but it is now rare. We found that the DAC implementation of loudness compensation works quite well and greatly increases listening enjoyment at low volume levels.

This feature works by taking over the tone controls and adjusting them automatically as the digital volume level is adjusted. As such, it has the same restrictions outlined above. In control mode 2, enable the tone controls and then press the 9 button on the remote to enable this mode. Making any tone adjustment immediately disables it.

With auto-loudness enabled, switch back to control mode 1 as described above and turn the volume down to hear the effect.

Crossfeed

This is a feature for headphone users. You may have noticed that headphones can sound unnatural, especially in recordings with wide stereo separation – the sound you are listening to can appear to come from inside your head and move around inside it!

This is because the headphones effectively provide totally separate sounds to each ear but normally, you can hear a sound in both ears even if it's coming from one side of your head. The sound waves still make it to the other ear, although attenuated. Crossfeed simulates this by delaying the sound for each channel, attenuating it, applying a low-pass filter and then feeding it across to the other ear (ie, "crossfeed").

The effect of the crossfeed feature is quite subtle but can be enough to remove the unnerving aspects of the stereo signal. As with the tone controls and auto-loudness, this only applies to WAV file playback at sampling rates up to 48kHz. To turn it on, press the "page hold"* (A1012) or TV/AV (AR1726) button and then press the OSD button. Another press of this button turns it back off so you can compare the sound with and without crossfeed (* = see Table 1).

Note though that the sound volume will drop slightly with it on, for the same reason as this happens with tone controls – ie, to avoid the signal clipping. You can combine crossfeed and auto-loudness or tone controls, if you wish.

The various parameters for this mode can be adjusted but the defaults chosen should work well for most people (see the list of remote control commands for the list of parameters that can be changed). Pressing the OK button while in control mode 3 will reset these changes while the TV/Video or Menu button can be used to get back to normal remote control mode as explained earlier (crossfeed will stay on if enabled).

Since crossfeed is only really useful when using headphones, it is automatically disabled if there is nothing plugged into the headphone socket. You can override this in the configuration file though (eg, if using an external headphone amplifier) – see below.

More remote control commands

Tables 1 and 2 show all the remote control commands. Many of these have already been explained. Note that some buttons change function depending on the current control mode; the DAC starts in control mode 1 but you can then switch it to 2 and 3 using the buttons indicated.

Some of the buttons on the A1012 remote are labelled with pictograms which many people won't recognise so we have put small images of these

Table 3: Standard Settings

Setting Name	Possible Values
Input	1, 2, 3, 4, 5, 6, 7, 8
Mute	true, false
Volume	0 to 255 (1 = -0.5dB, 2 = -1dB, 3 = -1.5dB etc; default = 0)
Balance	-20 to 20 (-20 = fully left, default = 0)
Init_File	<name of file to play first when card is inserted>
PlaybackOrder	sorted, directory, shuffle
Auto_Play	true or false (default = true)
Auto_Switch_Enabled	false, true (overrides DIP switch 2)
Auto_Switch_Delay	1-999 (seconds; default = 10)
AlternativeIRCodes	false, true (overrides DIP switch 3)
Tone_Enabled	false, true
Tone_EqualVolume	false, true
Tone_AutoLoudness	false, true
Tone_BassBoostCut	-16 to 16 (-16 = full cut, 16 = full boost)
Tone_BassCrossoverFreq	50 to 950 (in Hz; default = 500)
Tone_TrebleBoostCut	-16 to 16 (-16 = full cut, 16 = full boost)
Tone_TrebleCrossoverFreq	1000 to 5000 (in Hz; default = 2000)
Crossfeed_Enabled	false, true
Crossfeed_LPFFreq	50 to 5000 (in Hz; default = 1500)
Crossfeed_Delay	1 to 32 (in samples; default = 14 for about 0.5ms)
Crossfeed_Atten	1 to 5 (effect is halved as number increases; default = 3)

Table 4: Variable Extra Settings (All Are True/False; Default = False)

Setting	Function
StereoSwap	Swaps left & right audio channels
DownmixToMono	If true, output is a mono mix of left & right channels
Filter_Slowrolloff	Selects alternative DAC output filter (not recommended)
InvertPolarity	If true, output phase is inverted
NoFreeRunningPLL	If true, DAC runs at 44.1kHz when there is no valid digital signal
NoDeEmphasis	False, true (if true, disable de-emphasis support)
Crossfeed_IgnoreHPSocket	If true, crossfeed is not disabled when headphones not plugged in

alongside the names, to make them easier to pick out.

Settings memory

Virtually all of the settings which can be changed with the remote control are "remembered" by the DAC when it is put into standby and even if it is powered off. This includes not only volume, tone control, crossfeed state etc but also which WAV file is being played, the position in the file and so on. As long as you put the unit into standby before switching the power off, when you switch it back on, you will be right back where you were.

The circuit incorporates some components so that if power is lost while the unit is running, it will attempt to save the current settings. However, the power supply capacitors collapse relatively quickly so it may not always have time to do so. Hence it's always a good idea to go into standby before switching the unit off at the wall.

Some settings can also be changed by putting a configuration file on the SD card (see below). These are loaded at power-on or when the card is inserted and if present, will override whatever the current settings are.

Configuration file

The configuration file is an optional text file placed in the root directory of the SD card, named "DAC.cfg". It has one setting per line, with the setting name on the left followed by an equals sign (=) and then the value on the right. Tables 3 and 4 show all the possible settings. Settings not listed in the file will not be changed. Here is a sample configuration file:

```
Auto_Play = true
Init_File = \My Music\01 – First Track.wav
Tone_Enabled = true
Tone_AutoLoudness = true
Crossfeed_Enabled = true
Crossfeed_IgnoreHPSocket = false
```

Bootloader

Should you need to update the microcontroller firmware, eg, if a bugfix becomes available, this can be done from the SD card without the need for a programmer or even to open the case up. First, rename the new firmware file to DAC.HEX and place it the root directory of an SD card. Then, with the DAC off, insert the card in the socket and power the unit up.

The sampling rate LEDs will start a chaser pattern while it checks the HEX file against the existing firmware. If it's different, the unit will re-flash itself, using the eight input channel LEDs as a bargraph to indicate progress. Once programming is complete, the unit will boot into the new software and you can then remove the SD card and delete the file from it (it's no longer needed).

This "bootloader" function is particularly useful if you bought a pre-programmed chip and don't have a PICkit to reprogram it later if new software is made available.

That completes the description of how to operate the CLASSiC DAC. As is typical for our projects, the full software source code (around 9000 lines of C) is available for download from our website in a zip file. We will also supply a small document with an overview of the software and a brief explanation of how some of its parts work. **SC**

STOP THOSE INTRUSIVE MEAL-TIME PHONE CALLS!

By JOHN CLARKE

"DO NOT DISTURB!" Phone Timer

Do marketing companies conspire to call you right on dinner time? It certainly seems so! Or perhaps you want the phone to be out of action for an hour or so, while you take an afternoon nap? This little timer will solve both those problems and it will "remember" to put the phone back in action because we know how easy it is to forget!

You know how it goes – you sit down to dinner and you are savouring your first mouthful... and then the &(*%$ ^ phone rings.

It might be some nincompoop from a marketing company selling you something that you cannot possibly do without, or a call centre in India or the Philippines. Or it could even be one of your closest friends or relatives. Whoever. It doesn't matter – you don't want to talk – you just want to enjoy your meal.

Of course, you could simply take the phone handset out of the cradle ("off-hook" in 1950s telephone speak) and that effectively silences it . . . but then you realise a few days later that the phone has been awfully quiet. Doh!

And yes, many cordless phones have a "do not disturb" button but

the same problem applies; you forget to switch it back to normal operation.

Worse still, if you do want to have a nap, pushing the "do not disturb" button does not usually silence the phone completely; it will ring several times before it goes to message mode – which can be pretty frustrating if you are just drifting off to the land of Nod.

That's where our new "DO NOT DISTURB!" Phone Timer is such a good solution.

It connects in parallel with your phone, or one of your phone extensions if you have more than one (or with your cordless phone base station, if you don't have conventional phones).

Then, if you want to disable the phone you just press the Set/Start button a few times to set the time period you want and the phone will be muted. Callers will get the engaged signal – so they won't have to pay for a call.

You get peace and quiet for a preset 15, 30, 60, 90 or 120 minutes.

After the preset time has passed, the Timer will reconnect the phone.

If you finish your meal or nap or whatever earlier than you anticipated, (or maybe son/daughter/spouse/etc says they're expecting an absolutely vital call!) just press the End button to restore phone operation. Simple.

Features

- Five convenient time settings from 15 to 120 minutes
- Time set indication
- Time remaining indication
- Automatically returns phone to "ready" (on hook) after time-out
- Easy push-button timer setting
- End button

LEDs show the time

Three LEDs display the set time. With one LED on, they indicate 15, 60 or 120 minutes. Intermediate set times are indicated with two LEDs on, ie, 30 or 90 minutes.

When you push the Set/Start button the LEDs will show the previous set timer period. Further button pushes will cycle though the available times: 90, 120, 15, 30 and so on. Just pick the one you want.

Timer operation starts as soon as the period is selected. After five seconds, the LED (or LEDs) will flash at a one-second rate and they also indicate the next highest time-out period remaining. All LEDs extinguish at the end of the time-out period as normal phone operation is restored.

What happens if you lift a phone handset off the cradle while the unit is timing? That's a bit uncertain - it depends on your particular phone and how it reduces the DC voltage across the phone lines from a nominal 50V DC to around 6V or thereabouts. Either way, neither the phone nor the timer can be damaged.

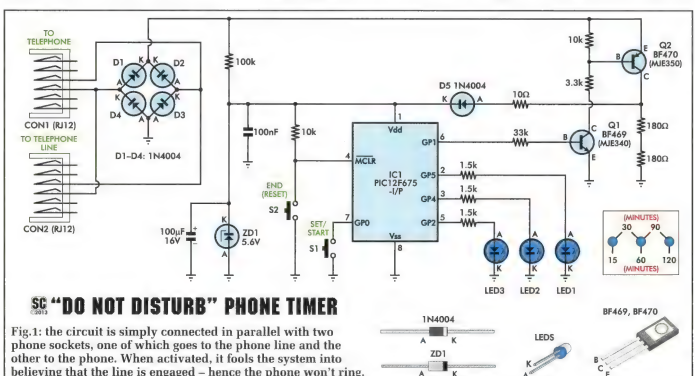
The DO NOT DISTURB! Phone Timer is housed in a small plastic box with the telephone line plugged into one RJ12 socket and the telephone into the second RJ12 socket, so you'll need a short phone "extension" cable .

Both the RJ12 sockets are located at one end of the box. On the top of the box are the two pushbuttons (Set/Start and End) and the timer indication LEDs. No batteries are required since the circuit is powered from the phone line.

Is it legal?

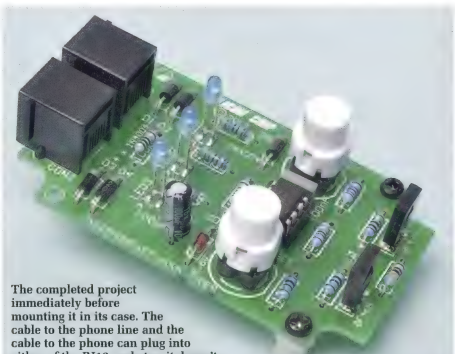
Strictly speaking, you aren't allowed to connect any non-approved device to the phone line, in case it causes damage to the line/exchange and/or endangers those working on the telephone system.

However, this device is powered by the phone line itself, so no dangerous



SC 2013 "DO NOT DISTURB" PHONE TIMER

Fig.1: the circuit is simply connected in parallel with two phone sockets, one of which goes to the phone line and the other to the phone. When activated, it fools the system into believing that the line is engaged – hence the phone won't ring.



The completed project immediately before mounting it in its case. The cable to the phone line and the cable to the phone can plug into either of the RJ12 sockets – it doesn't matter which way around.

voltages can possibly get back into the system.

Circuit details

Fig.1 shows the circuit which comprises an 8-pin microcontroller, a couple of high voltage transistors, three LEDs, some diodes and capacitors. The microcontroller provides the timing, switches the high voltage transistors and drives the LEDs.

There are two RJ12 connectors, CON1 & CON2 which provide connection to the incoming phone line and to one of the phones in the dwelling. These connectors are wired in parallel, so there is no break in the telephone line connection.

When the phone is not in use, (ie, "on-hook") there is about 50V DC present across the line. The bridge rectifier consisting of diodes D1-D4 feeds that 50V DC to the rest of the circuit and ensures correct polarity.

The microcontroller, IC1, is powered from 5.6V DC, derived via a 100kΩ resistor, zener diode ZD1 and 100µF capacitor. Thus the 50V from the telephone line provides about 400µA to ZD1 while IC1 draws about 100µA.

This current is low because IC1 is initially set in sleep mode where it is stopped from running, with its internal oscillator off. IC1 also has a brownout detector incorporated so that the slow start up voltage applied through the 100kΩ resistor and 100µF supply capacitor allows the IC to reset correctly.

Current draw is higher when the timer function is started with Set/Start switch S1. This current can be up to 10mA and the 100kΩ resistor across the telephone supply will not provide this.

We derive the extra supply current in another way. When the set switch is pressed, the GP1 output of IC1 goes high (to 5.6V) and this switches on transistor Q1 via its 33kΩ base resistor. Q1 in turn switches on transistor Q2 and this connects two series connected 180Ω resistors across the telephone supply. The load drops the telephone line to around 6V and it becomes "off-hook".

With transistor Q2 on, supply for IC1 is fed from the 6V telephone supply via a 10Ω resistor and diode D5. This provides the required extra current.

Q1 and Q2 are high voltage transistors, specified to cope with the high AC of around 140V peak-to-peak when the telephone rings.

Note if the handset (receiver) is lifted off the telephone, the DND Timer might reset. That's because of the extra load on the telephone line. If you still want to the DND Timer to work, you should hang up the phone and push the Set/Start button which will restart the timing cycle.

LED1 to LED3 are driven by their respective micro outputs at GP5, GP4 and GP2, each via 1.5kΩ resistors.

Normally, the GP0 input is pulled to the 5.6V supply via an internal pull-up resistor. This input drops to 0V when the set switch is pressed, waking up IC1 and starting the internal program running. IC1 goes back to sleep at the end of the time-out period. Both Q1 and Q2 are then switched off and normal phone operation is resumed.

IC1 can also be reset by pressing switch S2. This pulls the $\overline{MCLR}$ (Master Clear) low to reset the IC. Once released, the 10kΩ resistor to V_{DD} pulls the $\overline{MCLR}$ high and IC goes back to sleep with the internal oscillator stopped.

Construction

The DND Timer is constructed using a PCB coded 12104131 and measuring 79 x 46mm. It is housed in a small plas-

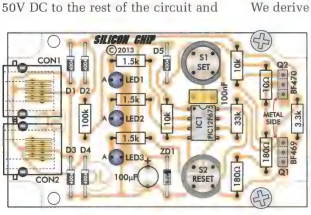
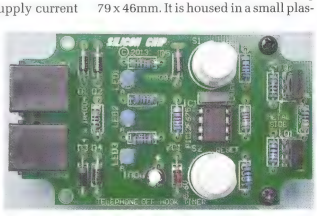


Fig.2 (left): component overlay with matching same-size photo at right.



tic box 83 x 54 x 31mm, used "upside down" – ie, the normal lid becomes the base and the four rubber "pips" which hide the case screws act as feet.

We used a translucent blue box (because it looks schmick!) but black or grey boxes of the same size are also suitable. A label measuring 48 x 78mm affixes to the lid of the box. If you use the blue box this label can go inside the lid and is thus protected against damage.

At one end of the box are located the two RJ12 PCB mount sockets. Fig.3 shows the details.

Before installing the parts, check the PCB for any faults. If you are using a board supplied from the SILICON CHIP Partshop or building from a kit, you will find that these PCBs are of excellent quality and rarely have any faults. If you do happen to find a fault (open track, hole not drilled etc) repair it before assembly.

Follow Fig.2 when installing the components. Install the resistors, diodes and the zener diode first. The resistors are colour coded and the table shows the colour bands for each resistor used.

A digital multimeter should also be used to check the values of resistance because it's easy to mistake red for orange or brown, especially on tiny resistors.

Make sure the diodes and zener diode are installed with the correct polarity – the striped end must be oriented as shown in the overlay diagram.

We use two types of IC sockets. One is the DIP8 socket for IC1, which must be oriented with the notched end as shown on the overlay diagram. Do not insert the IC into the socket yet.

The other sockets are DIP6 types used to raise switches S1 and S2 sufficiently above the PCB to protrude through the box lid. These sockets will need to be cut (using wire cutters) into two separate 3-way single in-line sockets and with the centre two socket pins removed before installing on the PCB. The switches must be inserted into these sockets positioned with the "flat" on the switch oriented as shown on the overlay diagram.

Capacitors can be installed next. The electrolytics are polarised – install them with the polarity shown. Likewise, transistors Q1 and Q2 must be mounted in the right positions and they must be oriented correctly – their metal sides face away from the PCB edge. Solder these in so that the top of the transistor body is 15mm above the top of the PCB.

LEDs need to poke through the top panel so are mounted with the top of each lens 17mm above the PCB surface. Make sure the LEDs are oriented correctly with the anode (longer lead) positioned in the pad marked 'A'.

We used blue LEDs, but you can use aqua, red, green, yellow, orange or white; whatever is your favourite. (You don't even need to use the same colours but you might end up with different brightness LEDs).

Testing

To test the DO NOT DISTURB! Phone Timer, firstly make sure that IC1 is still out of its socket and then plug the telephone line into one of the RJ12 sockets (you don't need the phone itself plugged in yet).

Measure the voltage across zener diode ZD1. This should be around 5 to 5.6V. Now unplug the telephone line and insert IC1 making sure the orientation is correct. Reattach the telephone line and the DO NOT DISTURB Timer should operate when pressing the Set/Start button by showing the timer LED or LEDs.

You should be able to select the required time-out period by pressing the switch until the required setting is displayed. Then the time-out LED or LEDs should flash after about five seconds from when S1 is released.

If the LEDs do not light, check the orientation of IC1. Also check that Q1 and Q2 have been inserted in the right

Parts List – DO NOT DISTURB! Timer

1 PCB coded 12104131, 79 x 46mm
1 panel label 48 x 78mm
2 UB5 plastic box, 83 x 54 x 31mm
2 RJ12 PCB mount sockets (Jaycar PS-1474, Altronics P1425) (CON1,CON2)
2 SPST PCB mount snap action round white switches (Jaycar SP-0723, Altronics S1099) (S1,S2)
1 DIL8 IC socket
2 DIL6 standard wiper contact IC sockets
2 10mm M3 tapped spacers (or use 9mm spacers with washers to make up the extra 1mm)
2 M3 x 6mm screws
1 300mm RJ12 6P/4C extension cable

Semiconductors

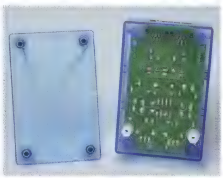
1 PIC12F675-I/P microcontroller programmed with 1210413A (IC1)
1 BF469/MJE340 NPN transistor (Q1)
1 BF470/MJE350 PNP transistor (Q2)
3 3mm high brightness LEDs (LED1-LED3)
5 1N4004 400V diodes (D1-D5)
1 5.6V 1W zener (1N4734) (ZD1)

Capacitors

1 100µF 16V PC electrolytic
1 100nF MKT polyester

Resistors (0.25W 1%)

1 100kΩ 1 33kΩ 2 10kΩ 1 3.3kΩ
3 1.5kΩ 2 180Ω 1 10Ω



The case is used "upside down) with the lid as the base. Here the PCB is shown fitted into the case.

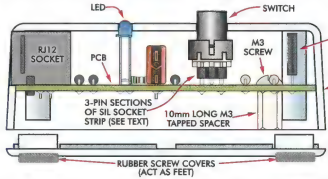


Fig.3: this diagram shows how it all goes together. The two switches are not soldered to the board but mounted instead inside some cut-down DIL sockets. This gives them some "play", making the board easier to fit in the case.

Where did these expressions come from?

We've talked about things like "off hook" and "on hook" in this article. You may also have heard expressions such as "transmitter" and "receiver" when phones are being described. But where did these expressions come from?

We thought we'd digress from our story with a little bit of telephone nostalgia!

Too long ago for most of us – but well within living memory for many – phones were rather different from what we have today. At right is a photo of an early wall phone, used on a manual telephone exchange (probably in the country) and this gives a good idea of where many of the terms came from.

There is a "receiver" (or earpiece) hanging on a spring-loaded hook on the left side. It's "on hook", it's ready to receive a call. Take the receiver off the hook to answer a call and, surprise surprise, it's "off hook". When the receiver is removed, the hook moves up and closes contacts inside the phone.

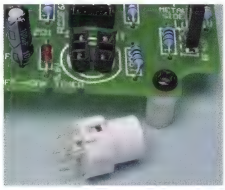
In the middle of the phone is the "transmitter" (you may think of it as the mouthpiece) while just visible on right side is a handle which you turned vigorously to attact the attention of the telephonist, or switchboard operator. This handle was attached to a generator inside the phone which produced the voltage necessary to ring a bell at the exchange.

Such generators were in big demand by schoolboys of the day because you could generate enough voltage to give your mates a decent (though harmless) "belt!"

In fact it was fun to arrange a ring of kids, all holding hands, with the generator connected to the last two in the ring so that all got the "experience!"

Low voltage DC was provided by a couple of quite large 1.5V batteries (hence the size of the box in the pic above) – also prized by kids of the day and the cause of more than one public phone being out of action until they were replaced.

One final bit of trivia: city visitors (used to automatic exchanges) to homes in country towns with manual exchanges almost invariably picked up the handset, or receiver, before turning the generator handle. Of course, the phone recognised this as being "off hook" and effectively shorted out the generator – so the exchange never answered. They couldn't understand why their country cousins always managed to make a call while they couldn't!



Here's a close-up of the way we mounted S1 and S2 in cut-down DIL sockets to allow easier assembly

places (Q1 is the BF469 or MJE340 and Q2 is the BF470 or MJE350) with the correct orientation.

Enclosure

As mentioned earlier, we use the plastic box upside down, with the switches and LEDs protruding through the base of the box instead of the lid.

We have provided a panel label for you to print out (available on our website www.siliconchip.com.au).

The RJ12 sockets protrude through a 27 x 15mm cutout in one end. The RJ12 sockets support the PCB in place at this end.

At the other end of the PCB, it is supported using two M3 tapped spacers. These spacers can be 10mm long or 9mm long with washers between the PCB and spacer to make up the extra 1mm length required.

The spacers are secured to the PCB with M3 x 6mm screws. We did not secure the other end of the spacers to the box since the PCB is held in position with the transistors preventing upward movement. Fig.3 shows the arrangement.

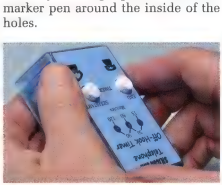
A diagram (Fig.4) is included which shows the positioning of the rectangular cut-out in the end of the box for the RJ12 sockets. The front panel label can be also be used as the template for the hole positions for the LEDs and switches.

Once drilled out, the front panel can be glued in with an adhesive such as contact adhesive or silicon sealant. Once the adhesive has cured, the holes are cut out with a sharp hobby knife and filed with a rat tailed needle file to clean up the panel edges.

The white edges of the photo paper inside the hole can be made less obvious by running a permanent black marker pen around the inside of the holes.

Shoe-horning in the PCB: first slide the board in at an angle so the two RJ12 sockets fit in their cutout.

Next, jiggle the switch buttons a bit so that they emerge through the front panel (ie, case bottom!) holes.



And finally, push the PCB up from underneath so the pushbuttons and LEDs poke through the panel.

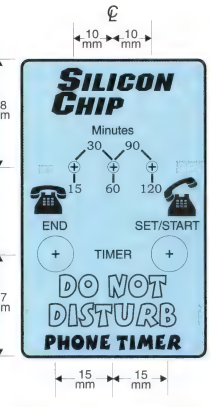


Fig.4: the front panel artwork and end-panel cutout diagram, which can be copied and used as a template. Both of these can be downloaded from www.siliconchip.com.au.

Inserting the PCB

So how do you insert the PCB into the box when it is used with the base of the box as the top panel?

There's an art to it but once you've done it, you'll find it easy. Simply angle the two switches slightly forward (toward the RJ12 sockets). The switches can be angled because they are inserted into sockets and so can be easily moved. Tilt the RJ12 connector end of the PCB at an angle to first insert these connectors into the cut-out in the end of the box and then rotate the PCB to lie horizontal to the box base. The switches will then enter the holes in the box top. These switches can be seated correctly into their sockets by pressing them once the PCB is in place. The 10mm spacer prevents the PCB from dropping inside the box.

To connect up to the telephone, connect the telephone line plug into one RJ12 socket of the DO NOT DISTURB! Timer and use the extension RJ12 lead to connect between the other RJ12 socket on the DO NOT DISTURB! Timer and the telephone. SC

Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	33kΩ	orange orange orange brown	orange orange black red brown
❑	2	10kΩ	brown black orange brown	brown black black red brown
❑	1	3.3kΩ	orange orange red brown	orange orange black brown brown
❑	3	1.5kΩ	brown green red brown	brown green black brown brown
❑	2	180Ω	brown grey brown brown	brown grey black black brown
❑	1	10Ω	brown black black brown	brown black black gold brown

The Avalon 2013 Airshow

The Australian International Airshow and Aerospace & Defence Exposition

By Dr DAVID MADDISON

Held every two years, the Avalon Airshow features an impressive array of technology ranging from the USAF's F-22A Raptor fighter aircraft to UAVs to robots, solar powered vehicles and satellites. Here's a quick look at what was on display at the 2013 show.

HELD FROM 26th February to 3rd March at Avalon Airport in Victoria, Airshow 2013 was an important international airshow and aerospace, defence and related technologies exposition. Avalon is about one hour's drive from the Melbourne CBD and is located in the Geelong area.

Students from Mueller College show their winning entry for the 2012 Airborne Delivery Challenge. The UAV is operated by a pilot and a mission manager whose job is to deploy a payload. The mission manager is not allowed to see the aircraft so a 5.8GHz video downlink is employed.

An impressive range of high-tech equipment was on show this year, including general aviation aircraft, aviation-related equipment and services (both civilian and military), solar-powered vehicles, robotics, 3D printing, imaging technologies, unmanned aerial vehicles (UAVs), air-traffic control equipment and satellites. These included many significant Australian contributions in various areas.

Among prominent themes in the military components on show, apart from aircraft and related equipment, were digital battle-space management, imaging, situational awareness, anti-ship missile defence and UAVs. Once again, there were significant contributions in these fields from various Australian companies.

It's impossible to mention everything on display in this article, so we'll just look at those most likely of interest to SILICON CHIP readers, starting with UAVs (unmanned aerial vehicles).

UAVs

Northrop Grumman's MQ-4C Triton was the largest UAV on display at this year's show. This UAV is under development for the US Navy as a maritime surveillance platform and is expected to enter service in 2015. It has a wingspan of nearly 40 metres, weighs almost 15 tonnes, has a service ceiling of over 18,000 metres, a mission duration of up to 30 hours, a top speed of 575km/h and is unarmed.

Northrup Grumman's MQ-4C Triton maritime surveillance UAV. It's unmanned but requires a four-man crew at the ground station.

Note that this UAV should not be confused with the similar-looking but armed General Atomics MQ-9 Reaper or MQ-1 Predator. These latter vehicles are "hunter-killers" and are properly designated as Unmanned Combat Aerial Vehicles or UCAVs.

Another UAV on show was the Heron from Israel Aerospace Industries. A number of these are used for supporting Australian soldiers in Afghanistan and are described by the RAAF as Remotely Piloted Aircraft (RPAs), to indicate that they are piloted from the ground. They have a mission altitude of up to 10,000 metres (with typical payloads), a duration of 20-30 hours (or up to 52 hours of continuous flight with lesser payloads) and a mission radius of 200-300km.

The Heron has a wingspan of 16.6m, a maximum take-off weight of over 1100kg and uses the popular Rotax 914 4-cylinder horizontally-opposed engine with water-cooled heads and a continuous power output rating of 73kW. It can either be directly flown from the ground by pilots in real time or it can automatically follow a pre-programmed flight path, including automatic take off and landing (with pilot oversight).

An impressive array of sensors can be carried such as radar and infrared and visible light cameras, along with other intelligence systems. In the event of a loss of communications, the aircraft will autonomously return to base. All mission data can be viewed in real-time by the pilots at the Ground Control Station (GCS).

UAV outback rescue

The "UAV Challenge – Outback Rescue" is a competition established by various government, industry and research organisations to promote civilian development and applications of UAVs in Australia. The challenge has two categories, one open to high-school students and the other open to Australian and international university students and aerospace enthusiasts.

The first category is the "Airborne Delivery Challenge" and involves delivering a small rescue package as close as possible to a lost walker located within a defined area, with an optional search component. The second category is the "Search and Rescue Challenge" and involves searching a 1km x 2km area up to 6km from the aerodrome and delivering a 500ml bottle of water to the lost walker.

The 2012 Airborne Delivery Challenge was won by students from Mueller College near Brisbane – see **http://www.uavoutbackchallenge.com.au/** for more information. The Monash UAS (Unmanned Aerial Systems) Team also displayed their UAV for use in the Search and Rescue challenge.

On a somewhat different theme but still on UAVs, the Australian Research Centre for Aerospace Automation (ARCAA) conducts world-leading research into advanced automated aviation systems for safer use of civilian airspace. This project is a collaborative effort between the Queensland University of Technology and the CSIRO. Areas of research include advanced automated flight systems such as autonomous guidance; sensors for various applications such as infrastructure inspection and agriculture management; multidisciplinary design and optimisation such as human-machine interaction and aviation risk management; and regulation such as airspace integration and management.

Another UAV on show was the AeroDrone MR4, made

An RAAF Heron UAV (Israel Aerospace Industries). It operates at altitudes up to 10,000 metres, has a range of 200-300km and can fly for up to 52 hours.

The AeroDrone MR4. Note the digital camera mounted in the payload area.

by the Australian company Bask Aerospace. It is a relatively small quad rotor UAV that weighs 1kg without a battery and can carry a maximum payload of 0.5kg. It has a mission duration of around 15 minutes and can be fitted with various sensors plus whatever payload is required.

An advantage of the design is that it can carry a fairly bulky payload beneath it due to its high ground clearance. Another interesting feature of this drone is the mission planning software which utilises Google maps and allows point and click entry of flight path waypoints.

Along with the Heron, numerous other military UAVs were also on display in an enormous range of shapes and sizes and with various capabilities. Interestingly, the UAV concept has been around for some time. In 1915, Nikola Tesla first described the idea of an armed unmanned aircraft which could defend the United States. Two years later, in 1917, Englishman Archibald Low, regarded as the father of radio guidance, demonstrated remote control of an aircraft and later a rocket.

Elmer Sperry, co-inventor of the gyrocompass, subsequently used an unmanned aircraft to sink a captured German battleship in 1919. Another interesting development around the time of World War I was the Hewitt-Sperry Automatic Airplane. You can read more about this aircraft in Wikipedia and elsewhere.

Piloted aircraft

Numerous aircraft were on display at the show, both as static ground displays and as flying displays. These included an RAAF Boeing 737 Airborne Early Warning and Control (AEW&C) aircraft, also known as the E-7A Wedgetail. Australia has six such aircraft which typically fly at an altitude of 10,000 metres.

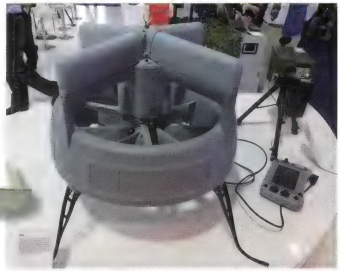
At this altitude, the radar can track multiple airborne and surface targets within a radius of hundreds of kilometres, allowing surveillance of about 400,000 square km at any given time. It can fly un-refuelled for up to 10 hours and also has an air-to-air refuelling capability for much longer mission durations.

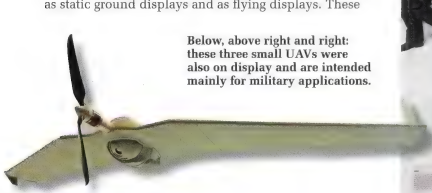
The E-7A is also equipped with a number of self-protection countermeasures, such as directed infrared, chaff and flares.

The RAAF also displayed a Boeing C-17 Globemaster III, one of six in its fleet. It can carry four times as much as a C-130J Hercules (also on display) and can even carry an Australian Army M1A1 Abrams tank (weight 62,000kg) plus support equipment. It is the second largest military transport aircraft in the western world and can carry a payload of over 77,500kg or 158 combat troops with their equipment (or various combinations of troops and equipment). The maximum take-off weight of the C-17 is over 265,000kg.

F-22A Raptor

One aircraft that attracted a lot of interest was a USAF





Below, above right and right: these three small UAVs were also on display and are intended mainly for military applications.

The F-22A Raptor stealth fighter – on display but closely guarded.

F-22A Raptor stealth fighter. This was on static display under high security and it also flew. The Raptor is the USAF's (and arguably the world's) premier air-to-air fighter and features low radar visibility (stealth), advanced sensors and impressive range, agility and speed.

An old favourite at the show was a USAF B-52 Stratofortress, the example on display having been built in 1961. It is still in service and is expected to continue for at least another 32 years until 2045 (ie, 84 years total). "If it ain't broke, don't fix it" as the saying goes – a beautiful and superb aircraft.

F-35 Joint Strike Fighter

USAF Lt General Chris Bogdan (Program Executive Officer of the F-35 Joint Strike Fighter Program) gave the media an update on the F-35 fighter. Australia intends to purchase 100 of these aircraft by around 2020, to replace its original F-18A Hornet fighters.

Whilst the F-35 JSF program has had various development problems and critics, he said that it is now largely on-track and that costs are decreasing (eg, the unit cost of the aircraft is now 50% of its projected cost five and a half years ago and each production lot will be cheaper than the last). The General said that he expects Australia will pay US$92 million for each aircraft ($80 million per airframe plus $12 million per engine) in 2020 (ie, in 2020 US dollars; not today's dollars).

Many of the problems were caused by the implementation of a high level of "concurrency" whereby aircraft are being simultaneously designed, manufactured, tested and flown. All military aircraft have a concurrent production strategy to a certain degree, otherwise the design process would take too long. It was the unusually high level of concurrency in the earlier part of the F-35 program that caused many of the problems, such as having to replace parts on already-built aircraft as the design specifications were altered.

There is now also much more oversight of the contractors by experts within the US Department of Defense and all important decisions are carefully scrutinised. Software development has improved as well and the aircraft has around 10 million lines of code on board, as well as another 10 million lines of code on ground support equipment. General Bogdan said that around 95% of what was (optimistically) promised will now be delivered with the aircraft which will have much better stealth, sensors, payload and survivability than other combat aircraft (except for the F-22A in some areas).

Anti-ship missile defence

The Royal Australian Navy's ANZAC Class Frigates are in the process of being upgraded with an improved anti-ship missile defence (ASMD). This upgrade includes the Active Phased Array Radar System from

The Australian-built Aerosonde G UAV is designed for military reconaissance and data gathering.

An RAAF E-7A Wedgetail. This Early Warning & Control Aircraft can maintain surveillance over an area of 400,000 square kilometres at any given time and can surveil up to 4,000,000 square kilometres on an unrefuelled mission.

The massive cargo bay of the Boeing C-17 Globemaster III can carry four times as much as a Hercules C-130J. The RAAF operates six of these aircraft.

Australian company CEA Technologies and comprises the CEAFAR Active Phased Array Radar and the CEAMOUNT Active Phased Array Continuous Wave Illuminator.

This radar system is capable of simultaneously tracking multiple sea, land and air threats, including incoming missiles which, along with other threats, can be designated for destruction. The upgrade involves removing the existing aft mast and replacing it with an entirely new structure comprising six fixed CEAFAR antenna faces and four CEAMOUNT illuminator fixed antenna faces.

Since phased array radars are electronically steered, they are mechanically very simple and much more compact than traditionally steered radar antennas. The system is fully integrated with the ship's combat system and can also share information with other ships in a task force, including those of our allies.

SolarDog is an Australian-developed solar-powered vehicle that's designed to be driven from Union Glacier to the South Pole and back again. The solar panel is mounted horizontally above the vehicle.

Solar-powered vehicles

Getting away from aircraft and avionics, the show also featured some impressive solar-powered vehicle technology.

SolarDog is an Australian-developed solar-powered vehicle that's designed to be driven from Union Glacier to the South Pole and back again. The "dog" in SolarDog, by the way, is a reference to the dog sled teams of the past.

The journey length is approximately 1100km each way and is expected to take 10 days in each direction. Apart from being a unique challenge, it is intended to demonstrate the feasibility of using solar-powered vehicles as a substitute for fossil-fuelled vehicles which are expensive and difficult to refuel in Antarctica.

This work also opens up the possibility of solar-powered autonomous vehicles roaming around Antarctica, taking measurements for research purposes. For more information see **http://www.solardog.com.au**

On a related theme, the Aurora Vehicle Association is a non-profit independent body of enthusiasts dedicated to "promoting sustainable mobility". Their "Aurora Evolution" solar car successfully competed in the 2009 World Solar Challenge from Darwin to Adelaide, coming second in its class, and this vehicle was also on display.

The Aurora Evolution has a lithium-polymer battery pack to power the vehicle when there is insufficient solar radiation. The battery alone can propel the car for around 500km.

The association has a new vehicle, known as the "Aurora Solaris" under development for this year's Solar Challenge. It will be road-registered and will also form the basis of a limited edition road-registerable car with an expected price tag of about $100,000.

The production version will be a 4-wheel solar-electric hybrid sports coupe, Australian road-legal and with a seating capacity of two in a side-by-side arrangement. It will have a luggage capacity capable of accommodating two carry-on bags.

Its range will be impressive for an electric vehicle and the claim is that it will be similar to a fossil-fuelled car. At 85km/h, using both the battery and the solar panel, it will have a range of about 675km and with battery only, a range of 425km at 100km/h. Its maximum speed will be 150km/h while the cruising speed will be 100km/h.

The vehicle's dimensions will be 4.5m long and 1.8m wide. For more information see **http://new.aurorasolarcar.com/**

Finally, the Victorian Model Solar Vehicle Challenge aims to have school students participate in fun engineering projects, building various types of solar-powered cars, boats and Mars rovers. For more information see **http://www.modelsolar.org.au**

Robotics

Moving along now to robotics, OzBot is a "ruggedised mobile platform" for use by military and law enforcement authorities. Developed by Deakin University's Centre for Intelligent Systems Research (CISR), it can

The top side of Aurora Evolution Solar Car with its solar panel raised for interior access.

relay video and audio streams to a hand-held controller. In addition, auxiliary devices can be attached to the vehicle such as an X-ray scanner to view the inside of a suspicious package (the X-ray scanner package requires the use of two vehicles).

Typically, it's designed to be used in applications such as under-vehicle inspections and site inspections where the area may be contaminated or hazardous. The device can navigate over rough terrain and can also climb stairs.

On the education front, Robogals is a scheme that uses university student volunteers to introduce school girls to engineering and robotics, to encourage interest for their future careers. It has chapters in Australia, UK, USA and Japan. For more information see **http://www.robogals.org/**

Another scheme, RoboCup Junior, is an Australia-wide competition for schools whereby students build and program robots and then compete against each other. There are three separate divisions comprising (1) Dance (in which robots are programmed to dance to music), (2) Rescue (in which a robot must follow a winding line and navigate obstacles before effecting a rescue) and (3) Soccer (in which two teams with two robots each compete on a field the size of a table tennis table).

For more information see **http://www.robocupjunior.org.au/**

Imaging

Some of the latest FLIR (Forward Looking Infrared) technology was on display, including two examples from FLIR Systems, one an analog system and the other digital. Analog FLIR units can be used on small aircraft and boats which either lack the necessary space for a fully digital system or simply don't require a digital system.

AEROmetrex is an Australian company offering aerial photography and photogrammetry. Their aero3Dpro product can take pictures from a variety of viewpoints and analyse the geometry of the image. It can then generate "geo-referenced" interactive 3D models which can be used for a wide variety of purposes.

Air traffic control

Airservices, an Australian-government corporation, displayed their new suite of air-traffic control tower technology known as INTAS (Integrated Tower Automation Suite). INTAS combines flight and operational data, surface surveillance radar and voice communications into an integrated layout. It also serves to replace paper "flight progress strips" with electronic versions.

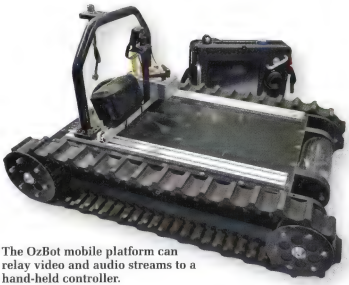
This interior view of the Aurora Evolution shows the rectangular battery pack on the left, the various control electronics and the cockpit.

Satellites

BLUEsat (Basic Low-Earth-Orbit University of NSW Experimental Satellite) is an all-student project of the University of NSW. Its function is to act as a digital amateur radio satellite.

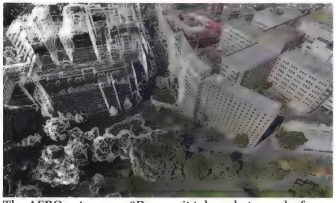
Intended to replace other amateur satellites which are now ageing, the new satellite is cube-shaped, measures about 260mm per side, and has a weight of 14kg. It will be placed in polar orbit at an altitude of around 750km, will orbit every 90 minutes and will utilise a passive stabilisation system. This system uses on-board magnets which cause the satellite to align itself with the Earth's magnetic field.

Voice and data files will be able to be uploaded to the satellite and retrieved by others, either in real time



The OzBot mobile platform can relay video and audio streams to a hand-held controller.

Above: RoboCup Junior students display their robots. RoboCup Junior is an Australia-wide competition for schools in which students build and program robots and then compete against each other.



The AEROmetrex aero3Dpro unit takes photographs from a variety of angles and uses these to generate interactive 3D models, including both outline and solid models as shown in this reproduction.

where line-of-sight exists between two ground stations or later when a communications link can be established. For more information, go to **http://www.bluesat.unsw.edu.au/**

Also under development at the University of New South Wales is their QB50 CubeSat. QB50 is an international collaborative project involving the simultaneous launch in 2015 of 50 cube satellites made in various locations around the world. These satellites will be placed into a circular orbit in a "string of pearls" formation and will be at an initial altitude of 320-380km at an inclination of 79° in a circular orbit. They will be used to research the lower thermosphere and will also be used for re-entry research to validate various re-entry predictive models. For more information, see **http://www.acser.unsw.edu.au/projects/QB50.html**

Two FLIR units from FLIR Systems. The top one is an analog unit while the bottom one is digital.

CubeSats, by the way, are a standardised type of low-cost satellite the size of a 10cm cube although they can be multiples of 10cm units in one dimension if extra size is required. A double-cube satellite is referred to as 2U (units) etc. The UNSW cube satellite will be 2U in size.

In summary, the Avalon Airshow is of significant international importance and it helps Australia strengthen its contacts with allied nations. As well as involving major corporations, militaries and governments, it also showcases an impressive level of youth participation in various projects. SC

Issues Getting Dog-Eared?

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PRODUCT SHOWCASE

Who is Weller?

Weller is a German manufacturer of quality soldering equipment distributed across the globe. The origins of Weller go back to 1945 where they have built a strong and trusted brand ever since.

They have a major manufacturing facility in Besigheim Germany consisting of state of the art manufacturing and a strong research and development team constantly creating innovative products with features and benefits that the end user wants.

Weller are owned by the USA-based Apex Tool Group. Two years ago Danaher Tools and Cooper Tools entered into a 50/50 joint venture and formed the Apex Tool Group. With that joint venture came powerful brands like Weller, Crescent, GearWrench, Jacobs Chuck and Allen keys. It is worth mentioning that Xcelite and Erem specialist electronics tools also form part of the product offering in Australia.

Weller Australia is well placed to service your soldering needs, with a 7,500 square metre warehouse and repair workshop located in the NSW town of Albury. Weller has sales people in every state and Australian technical support. One big advantage of being a Weller user is that you have access to the manufacturer for technical issues. The German Weller team is extremely proud of their product and if something is not working as it should they want to know about it and will offer a solution.

As Apex Tools is the manufacturer, distribution is handled by a number of trusted suppliers as listed below: RS Components, element14, Radio Parts and Oritech in Melbourne, Bondline, WES Components and Mektronics in Sydney and Ron Enright in New Zealand.

chipKIT uC32 & WiFi Shield Boards

Microchip Technology Inc. and Digilent, Inc. have announced two new pre-assembled boards which enable hobbyists and academics to easily and inexpensively add a 32-bit microcontroller and Wi-Fi connectivity to their projects, even if they don't have an engineering background.

The first of these boards, the chipKIT uC32, provides a development platform for users to create a wide range of 32-bit microcontroller-based applications using a free, Arduino-compatible development environment. This open-source development platform includes Microchip's 32-bit PIC32MX340F512H microcontroller, with 105 DMIPS (Dhrystone million instructions per second) performance, 512KB Flash program memory, 32KB SRAM and 42 I/O pins that support a number of peripheral functions such as UART, SPI and I^2C serial ports and pulse-width-modulated (PWM) outputs.

The second board is the chipKIT Wi-Fi Shield which enables users to implement wireless projects when used with the chipKIT line of microcontroller boards such as the new uC32, or existing Uno32 and Max32 boards. The chipKIT Wi-Fi Shield uses Microchip's MRF24WB0MA Wi-Fi module, and provides chipKIT microcontroller boards with the ability to communicate via IEEE 802.11-compatible wireless networks. The Wi-Fi Shield also has a microSD card connector for use with microSD Flash memory cards, giving additional persistent storage for the connected microcontroller.

Both of these new boards can both be purchased today, at microchipDIRECT or Digilent's e-Commerce site. For more information, please visit the Digilent website at www.microchip.com/get/T23G. More information is also available on Microchip's website at www.microchip.com/get/9AAD, as well as the online chipKIT forum and Wiki.

JBL smashes the portable sound barrier

The JBL Micro II delivers outstanding sound from a speaker that fits neatly into the palm of your hand. The ultra-portable speaker can also be clipped to clothing or bags and can easily slipped into a handbag. They are ideal for business travel, holidays and the beach – in fact, anywhere you need to amplify the sound from your portable music player. The Micro II is available in black, white and orange.

The pocket-sized JBL Micro Wireless easily pairs with any Bluetooth-compatible device – including iPhone, iPad, Android phone, tablet or BlackBerry – and provides great sound. It can be daisy-chained to other JBL Micro speakers for a bigger impact. The range now comes in several colours, including green, red and blue as well as black.

Both the Micro II and Micro Wireless can be daisy-chained to deliver an even bigger, fuller sound. They have inbuilt rechargeable lithium-ion batteries for maximum convenience and versatility and will deliver up to five hours of uninterrupted music playback.

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Website: www.ehifi.com.au

AAAGH!

Does your Digital Multimeter lack an auto power-down facility? Many don't – and if you forget to turn it off, next time you go to use it you might be tempted to say naughty words. This little circuit, which will cost just a couple of dollars, will stop a DMM chewing through batteries when you forget to turn it off.

While this auto simple power-off circuit is intended for Jaycar's tiny QM1502 DMM, this could be applied to many other battery-operated devices.

By Stan Swan

Shoppers in Jaycar stores may have spotted their cute new orange QM-1502 mini DMM (digital multimeter) and wondered if such throwaway-priced "toys" can be serious!

At its bargain price – five bucks – it's hard to know if one should laugh or cry at such trivial test gear prices. I recall (as an early teen) paying ~$500 in today's money for a *far* inferior analog meter. For schools and hobbyist needs they look extremely appealing – you can never have too many multimeters of course!

But, even at only $5, are they worth a punt?

Although superior meters abound in the $40 range (and should certainly be considered for those serious about electronics), this little DMM merits a closer look for newcomers, schools and hobbyists.

With dimensions of just 94(H) x 46(W) x 26(D)mm it's almost laughably tiny (the footprint being smaller than a credit card) but range settings are very clear and the display is just as bright and clear.

Build is surprisingly good, with a sturdy switch action and current drain an astoundingly low 250µA from the small cylindrical A23 12V battery. A full set of normal electrical readings, even including transistor gain, are featured.

The (unfused) 10A DC current range remains usefully connected even with the meter turned off – handy perhaps for occasional monitoring of a photovoltaic solar array or battery charger.

The 12V supply voltage is not critical and the DMM runs well from a fresh 9V battery, with the "low batt" symbol only showing at around 7V. Demand current, which "surged" to 400µA on resistance with shorted leads, otherwise remains near 250µA.

Aside from newcomers, schools and toolbox spare use, the DMM is also suitable as an inbuilt panel meter. That's right – just switch it to the setting you want, internally

An A23 battery might be rated at 12V but the opened-up view at right shows why they don't have much capacity – they're merely eight button cells packaged together.

I forgot to turn the DMM off . . . again!

connect leads and supply and build it into the project!

Note however that it's not possible to power the DMM from the same circuit that you are monitoring. This arises because many basic DMMs use a classic ICL7106 COB (chip-on-board) for measuring and display. The "COM" socket on such meters is at 3V lower potential than the +ve terminal of the battery inside, as such an arrangement also allows negative voltages to be measured.

So what's the downside of such a cheap meter?

Several weak points emerge. For example, the meter sensitivity (or insertion resistance, if you like) is only around 1MΩ (most DMMs now are far better) and the supplied probes are low quality – do not trust them for mains work! We also found some difficulty in inserting the leads into the multimeter sockets – they do go in, but. . .

The leads can readily be upgraded (you'll probably pay as much for better leads than the whole DMM, perhaps more!), Or you might like to replace the test probe ends with some more sturdy crocodile clips.

Even with decent test leads we sill have a major reservation about safety. While the DMM has ranges for 500V AC and DC, we'd be very hesitant about using it for this type of measurement.

In fact, we'd go so far as to say it should only be used on low voltages – 50V AC or DC – and we've even prepared a warning label to stick on the meter.

No auto off

However, the meter's most annoying attribute (or non-attribute!) is the lack of auto-power-off. Despite the multimeter's low current drain, the low capacity of 12V A23 batteries (which are merely eight button cells packaged together) means that you're likely be plagued by flat batteries, especially if you forget to turn it off.

And A23 batteries can be elusive and costly (often around $5) – which may exceed the cost of the meter!

As alkaline A23 batteries typically have a 55mAh capacity, only a few dozen hours or so of operation will result before the supply drops too low. Although tolerable for a conscientious user, this equates to approximately a weekend, so failure to turn off the meter on Friday will likely see it flat by Monday.

Educators who've found their class meter batteries dead mere minutes before 30 surly youths arrive for a Monday school lab session will keenly appreciate this particular "electro-angst"...

Even with meagre supply needs, it makes no sense to leave devices wastefully on when battery replacement costs are high.

What to do?

Several supply workarounds were considered, with an eye to cost effectiveness – it's unjustified spending much more than the ~$5 meter cost on enhancements!

Space inside the meter case is tight but there's enough for some additional compact circuitry, although simpler approaches may appeal (if only for constructional ease).

In approximate order of complexity, these include:

External 9V battery supply: Alkaline types of ~500mAh capacity (of which perhaps half will be available before the supply falls below 7V), are cheaper than A23 (but not much!) and are very widely available. They won't fit inside the QM-1502 case but could be readily mounted externally, perhaps along with a supply switch. For many users this approach may be appealing.

Case mounted switch: A dedicated supply switch can also prolong the life of the DMM's rotary switch, as a pre-selected range can remain ready for immediate use at power up.

(Many a DMM fuse is blown by "knob twiddlers" when

This is what the DMM looks like when it's opened up. Shown here very close to life size, you can see that there's room on the inside back of the case to add a simple auto power-off circuit.

meter current ranges are selected with the meter paralleled to the supply!) In conjunction with a low drain LED (often still visible at a mere few hundred microamps), a still-powered meter would then readily be noted in a dark storage cupboard.

Solar Power: Although using a few tiny photo-voltaic cells from cheap calculators or solar garden lights (most provide ~3mA at several volts) is tempting, an array to supply >7V would be difficult to neatly mount on the front of this small DMM. Meters are often used in poorly lit places indoors as well.

Orientation switch: Mercury position switches (Jaycar SM1044) are relatively costly and may annoy users when the meter is in unexpected working positions.

Auto power off – microcontroller or IC: The popular PICAXE-08M microcontroller can shut down totally after some minutes but a sleeping PICAXE will draw tens of microamps, which over time will still drain batteries.

Such an approach is rather an overkill anyway, as of course a micro can do far more! Additionally, the cost of the IC and extra components will likely exceed that of the DMM.

"Joule thief" step up: Solar garden lamps use step-up circuitry to drive a 3-4V white LED from a single AA(A) sized battery. Although higher voltages are possible, they're at very reduced currents and with rough output, requiring smoothing and regulation.

Auto-power-off capacitor discharge: As users are now familiar with such modern devices as cameras, cell phones and PCs going "touch to revive", a simple switched discharging electrolytic was considered. Quick tests with a 4700µF electrolytic confirmed several minutes hold up until the ~7V "low battery" display came up.

This is readily verified by $Q = I \times t = V \times C$, when a 250µA drain at 12V should fall in one time constant (T) to 1/e (37%) of the original voltage (12V x .37 = ~ 4V. Hence the time constant = $12 \times 4700 \times 10^{-6}/(250 \times 10^{-6})$ = ~200 seconds.

This approach could suit push switch operation for quick checks (perhaps of circuit charge/discharge currents or supply voltages) but power will only be held on for few minutes. This time will be too short for most users, and can only be extended with larger value capacitors (10,000µF+), or even super-caps,which will be bulky and perhaps costly.

Auto-power-off – FET capacitor discharge: John Crichton's recent "Circuit Notebook" time-out switch (SILICON CHIP January 2013) showed most promise and has been the approach adopted.

Small signal FETs

High gain Darlington bipolar-based auto-power off circuits exist but the popular (and cheap) 2N7000 (N-Channel enhancement mode FET with an insulated gate is superior as, being a FET it has negligible gate current.

A major practical benefit of such gate supply switching is that only low value (10-100µF range) electrolytics are needed, which are cheaper and fit better in the DMM's case than larger types.

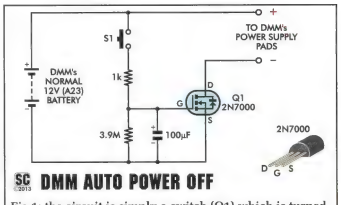


Fig.1: the circuit is simply a switch (Q1) which is turned on by pressing S1 and it turns the DMM off once the 100µF capacitor discharges, to conserve the battery.

A breadboard trial with the 2N7000 verified that a momentary push on the switch, with a 100µF electrolytic, paralleled with a 3.9MΩ across the gate, held the meter on for about 10 minutes before the low battery symbol appeared.

This period should be enough for most users but could be readily altered with different value discharge resistors,

An A23 battery, with its 350µA drain could stretch to perhaps hundreds of such test sessions.

Simple components are used, and the total bill of materials should only be a few dollars. The benefit of such an enhancement may be educational as well as financial, especially for those fresh to electronics.

A "hands on" understanding of RC discharge and FET action should result and organising the few components to fit the DMMs interior may help new comers develop skills with compact circuitry.

Construction

For such a simple circuit, a PCB is hardly warranted (and would likely cost as much as the DMM).

Therefore a small (5x5 hole) Veroboard offcut was used and the components connected as shown in the wiring diagram. The electrolytic capacitor will not fit into the case if soldered onto the Veroboard in the normal way – it is laid over off the Veroboard and parallel to it, as shown.

The supply wiring (ie, from battery to the DMM PCB) was then connected as shown in the diagram. You only need to unsolder two of the wires (ie, those going from battery to the PCB) and connect wires from your Auto Power-Off

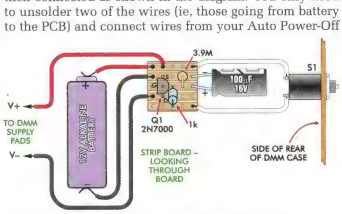


Fig.2: a suggested Veroboard layout and wiring diagram. The Veroboard and 100µF electrolytic capacitor can be secured to the DMM case with double-sided adhesive.

The finished modification. There's not much to it but note that you'll almost certainly have to lay the electrolytic capacitor over to get it to fit in the case. Otherwise, it's just a matter of breaking the positive and negative leads from the battery and inserting the auto turn-off PCB.

switch in their place.

Finally, carefully drill a hole in the side of the case (back section) for the pushbutton switch (its diameter will depend on the exact switch you use).

There is a ridge all around the case and unfortunately the hole needs to go through the case where the ridge steps down. But once tightened properly, this should not be a problem.

Depending on the size of your switch, you may need to mount the Veroboard underneath the battery compartment – if you do, make sure it's as close as possible to the battery to avoid interference with the current shunt in the DMM (the thick copper wire near the terminals at the bottom of the case).

Similarly, make sure it doesn't interfere with the on-board fuse.

We used a switch probably larger than necessary, originally to maintain the isolation between contacts and outside. However, with our comments about using the DMM on 50V or less, a much smaller switch will suffice.

If you do use the switch we used (a Jaycar SP-0702) you might like to remove the large red knob and cut back the actuator a little.

One further enhancement also makes the meter more "user friendly": marking the setting arrow more boldly with a spirit-based pen ensures correct settings.

While the arrow and markings are obvious in bright light, they are much less so in dim light!

Speaking of light, we've found that some of these meters are sensitive to bright sunlight (affecting readings). This can be simply cured with a piece of black electrical tape over the back of the chip (the black blob!).

Finally: don't twiddle the pot!

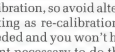
Note – the potentiometer, or variable resistor, in the DMM is used for calibration, so avoid altering its factory setting as re-calibration may then be needed and you won't have the equipment necessary to do this. SC

Parts List – DMM Auto Power Off

(all available from Jaycar/Altronics/etc):

1 NO momentary pushbutton switch
1 2N7000 FET or equivalent
1 100µF 16V electrolytic capacitor
1 scrap of Veroboard (5 x 5 holes)
Short lengths of red and black hookup wire

Resistors (1/8 or 1/4W, 5%)
1 3.9MΩ (orange white green gold)
1 1kΩ (brown black red gold)



Noting our comments about safety, this warning label can be printed and glued to the top front of the case, as shown earlier.

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RF Explorer:

The spectrum analyser that fits in the palm of your hand

How much would you expect to pay for a sophisticated portable, but PC linkable UHF spectrum analyser? Thousands?

UHF "frequency domain" (frequency versus signal strength) test gear analysers can indeed be very costly and sometimes bulky and difficult to master.

Typical of budget spectrum analysers is the well thought of TTi PSA2702, costing almost $2000.

Advanced test gear is called for when sensing and displaying weak, complex, interfering or transient signals over wide-band UHF (300MHz to 3GHz).

For RF transmission, circuit and antenna testing, a spectrum analyser is viewed as an essential tool, comparable to a multimeter for DC or oscilloscope for AC. When setting up professional cellular networks, TV, telemetry links or live event broadcast and control systems it would be foolish to even consider skin-flint approaches.

Steep commercial RF test equipment prices may be tolerable for professionals on reliability grounds – it'd be a concert nightmare if potential stage mic interference was missed by simpler gear.

Unless checked and isolated, the likes of CB chatter from a passing truckie could blight Mike Jagger's vocals, a wireless door-bell frustrate a security system, a theatre's softly-spoken Lady Macbeth be cursed by a cell phone texting or a nearby radio amateur torment a studio broadcast.

However, for those of us not setting up Rolling Stone concerts or theatrical events, UHF spectrum analysis test gear can be dauntingly costly.

Budget monitoring at sub-GHz frequencies can normally only be done with a UHF scanner and scanning (although rapid) usually requires prior entry of channels. Although Uniden's range offer "close call" features, weaker interference nearby may be missed.

UHF scanners are also usually optimised for FM reception and the increasing sub-1Ghz digital data transmissions may be ignored.

This is of particular significance around 700MHz, as there's a move to free up UHF analog TV spectrum for more efficient digital TV and 4G cellular use.

"Hands On" Review by Stan Swan

RF Explorer

It's therefore pleasing to see the cost-effective "RF Explorer". At prices an order of magnitude cheaper than professional

analysers but with features approaching those of the big boys, the RF Explorer increasingly looks like a game changer!

Background

RF Explorers are the brainchild of Spanish engineer Ariel Rochell, who designed them to monitor the nearby RF spectrum while flying radio controlled models. In many parts of the world 433MHz and 868MHz bands are a "soup" of potentially interfering signals and such band monitoring can be extremely beneficial in preventing plane loss or accidents.

Uptake of the RF Explorer has been rapid, not only by radio control modellers but also general UHF users. The device is now manufactured by Seeed Studio – a Chinese electronics supplier. Agents are also active in most countries, including Australia and New Zealand.

The units come in several variants, with the top WSUB3G/3G covering from 15MHz to 2.7GHz and costing $US269 (on the manufacturer's website with free shipping).

The slightly more sensitive, much cheaper ($US129) WSUB1G model evaluated here covers from 240MHz to 960MHz and looks the most appealing and cost-effective version for many UHF users. An add-on 2.4GHz expansion module (and second antenna) is available if required.

The Explorer uses a powerful Microchip PIC24FJ64GA004 16-bit microcontroller to control the SiLabs (Silicon Labs) Si4432 transceiver. Some model variants use this as an internal signal calibrator.

SiLab's thumbnail-sized Si4432 is a popular RF engine in many current UHF devices, with Chinese firm Dorji using them in their 433MHz data transceivers. (Dorji's recent DRF4463D20 in fact uses a newer SiLab Si4463 RF IC, although the Si4432 has superior frequency coverage).

The units are nicely assembled, with a very clear backlit mono LCD and outstanding battery life. Perhaps the only initial concerns relate to a very small on/off switch, buttons that tend to "click", a bottom mini-USB socket and the lack of audio output.

Features and specifications

The RF Explorer makers claim "90% of what a high cost unit will do at 5% of the price". Can they be any good at such user-friendly prices?

A feature check of the budget WSUB1G model is reassuring::

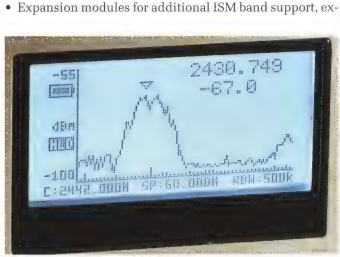
- Pocket size and light weight (185g) – solid aluminum metal case (113 x 70 x 25mm).
- Wide band coverage, from 240MHz to 960MHz - suiting all popular sub-1GHz ISM bands (315, 433, 868 and 915MHz), plus UHF TV, PRS, 70cm and 33cm ham radio, GSM etc.
- Spectrum analyser mode with Peak, Max, Hold, Normal, Overwrite and Averaging modes.
- User-friendly push-button controls.
- High capacity lithium polymer battery, USB 2.0 rechargeable.
- Open-source Windows (XP/Vista/Win7) and Mac client software.
- Selectable frequency span: 112kHz - 100MHz
- Mono (backlit) 128x64 pixel graphics LCD for good visibility outdoors.
- Standard SMA 50Ω connector – wideband Nagoya NA-773 telescopic antenna included

It was originally developed to check the spectrum around 433MHz for radio-controlled aircraft operations.

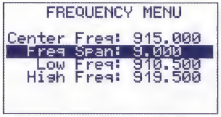
- Amplitude resolution: 0.5dBm.
- Dynamic range: -115dBm to 0dBm
- Absolute maximum input power: +5dBm.
- Average noise level (typical): -110dBm
- Frequency stability and accuracy (typical): ±10ppm
- Amplitude stability and accuracy (typical): ±3dBm
- Frequency resolution: 1kHz.
- Resolution bandwidth automatic 2.6kHz to 600khz
- Extendable via internal expansion modules for additional bands and functionality.
- Lifetime free firmware upgrades available, open to community requested features.

The online firmware upgrades are particularly appealing, and anticipated future extensions include:

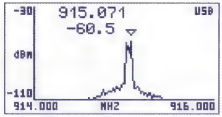
- Transmission test tones in OOK and FSK (On-Off and Frequency Shift Keying)
- Digital transmission decoding and packet sniffing for OOK and FSK, including Manchester code support
- Logging features for multi-hour transmission monitoring
- Frequency counter and automatic peak detection
- Storage for up to five screenshots in internal memory or thousands of screenshots in expanded memory.
- Expansion modules for additional ISM band support, ex-



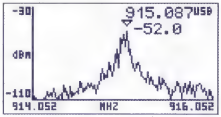
A close-up of the RF Explorer screen showing, in this case, a Wi-Fi signal on 2430.749MHz. This is made possible with an add-on module – the normal upper limit for the economy model RF Explorer reviewed here is 960MHz.



"Front panel key presses show on the LCD screen, and control configuration of frequency span and bandwidth,as well as selecting diverse signal display options.



Here's a narrow bandwidth GFSK (Gaussian Frequency Shift Keyed) data signal. Note how little spectrum space this superior filtered signal occupies. The narrower bandwidth makes for a more sensitive receiver as well.



In contrast a similar FSK (Frequency Shift Keyed) data signal has a much wider bandwidth, and may be wasteful of spectrum."

panded RF Generator and Tracking Generator for circuit analysis, etc.

Hands on

Seven front panel keys control operation, which is fairly intuitive. "Menu" initially selects operational mode (with only one being available on the budget model) and further clicks to comprehensive Frequency, Attenuator and Configuration menus.

Up and down arrow keys allow option selections. "Enter" toggles through (and also freezes a display) while "Return" goes back. The left and right arrow keys control displayed frequency span and bandwidth (ranging from 600kHz down to 2kHz).

The higher setting allows 100MHz wide band monitoring, while the narrower setting shows increasingly tighter spectrum slices that suit individual signal analysis.

Displayed frequency was found pleasingly accurate, with resolution being best at the lowest 2kHz bandwidth. A handy way to confirm calibration is via a UHF CB PRS transceiver on low power. However this should NOT be too close to the RF Explorer as overload may occur. Perhaps even remove the SMA antenna entirely?

A check with several 40-channel Uniden UH039P transceiver on channel 24 (nominally 477.000MHz) showed all uniformly transmitting on a close 477.005MHz .

Many users will soon settle on a band of interest, and be content to use the unit as a portable monitor, perhaps when setting up 433MHz equipment. However connecting via USB cable both charges the inbuilt battery and allows comprehensive client (Windows/Mac) software to be run. (Windows requires Microsoft's .NET Framework version 4 (or higher) to be installed.)

Client software is not just limited to the official version, as Stage Research's "RF Scanner" allows for both continuous monitoring of the spectrum and valuable alerts when designated signals go beyond a programmable threshold.

Applications

The unit proved especially convenient for quick spectrum checks to see "just what's going on" nearby. This relates not just to signal detection but thanks to the signal strength reading, detailed display of signal level.

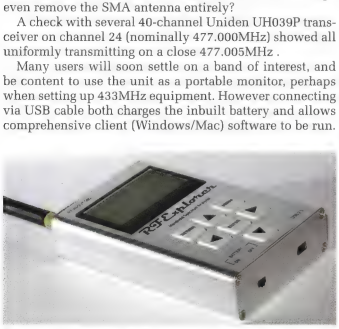
Changes to the latter may arise from alterations to transmitter power, antenna or feed lines but may also relate to propagation obstructions.

Path obstructions become increasingly significant at high UHF, as even seasonal vegetation changes or weather may significantly attenuate signals. The rise of "all or nothing" digital TV at ~600MHz increasingly requires good signal levels and rooftop antenna sweet spots to be located; tasks readily performed with an RF Explorer.

The Nagoya telescopic whip strictly covers 144- 430MHz but is usually satisfactory for quick spectrum checks at other frequencies. Naturally, specific band antennas should be used on higher frequencies.

As these will be short (at 900MHz a quarter wavelength is just ~75mm long), simple resonant lengths can easily be made from scrap wire and connected via adaptors.

Various SMA adapters are readily available, with Jaycar's SMA socket to BNC socket (PA-0624) particularly suitable. A short extension lead could also be used to ease wear and



(Above): a switch and USB connector are on the bottom of the case, necessitating it be raised above bench level. Fortunately, a low-cost "desk stand" is available to support the RF Explorer (see right).

(Above): a simple jumper lead is essential if you are continually swapping antennas.

tear on the unit's SMA antenna socket, as this may eventually fail with continual antenna changes.

Interference location

All manner of signals abound on the licence-free 433MHz ISM band, and interference may blight activities. Hobbyists may also yearn for a simple *"is my %$#@&! transmitter actually working?"*

A BNC to Banana socket adapter (Jaycar PA-3666) or BNC-Spring terminal (Jaycar PA-3715) readily accepts stiff wires at its double binding posts and with these each trimmed to ~160mm a simple half-wave dipole results. (The adapter's internal wiring contributes some antenna length too of course).

Rotation of this antenna to maximize displayed signal level, along with simple readings from several locations readily allows a fix on the nearby interference source. Naturally a more directive Yagi antenna could do this with some precision!

Transmitter

Placing the RF Explorer near a 433MHz transmitter will readily show the signal presence, nature, duration, frequency and relative strength. Improvements in signal strength may well relate to finding an unobstructed and elevated take off position for the likes of a backyard wireless weather station.

For omni-directional work at 433MHz a simple quarter-wave vertical whip is common, although some uncertainly often arises over the best length, especially in tight enclosures. Connecting a stiff piece of bell wire to a BNC-RCA adapter (Jaycar PA-3654) readily allowed it to be snipped progressively shorter while monitoring the received signal strength. Much as theory predicted, the best performance occurred at ~165mm.

Conclusion

At such a bargain price and considering the enhanced features, the RF Explorer looks like an indispensable portable test item for almost anyone working with higher frequency radio signals.

The increased popularity of the 700-900MHz spectrum makes them especially prized, as off-the-shelf monitoring gear in this sub-GHz band can be elusive or costly. Antenna designers and installers alone may find them an answer to their prayers, as they quickly assess relative antenna and feed line performance, as well as locating UHF signal sweet spots that terrain may otherwise obscure.

As a tribute to the RF Explorer's niche popularity the NZ agent (Sound Techniques-Auckland) reports that interest arising just from passing inspection of my evaluation unit has already lead to several local sales. These little darlings sell themselves!

Where can you get one?

The choice is via local agents or online. The designer has just emailed me to say "We have an official distributor in Australia, www.soundlabsgroup.com.au".

However, SoundLabsGroup doesn't have a dedicated page for RF Explorer yet but hope to have one up by the time this issue is released.

Alternatively, in New Zealand Sound Techniques (www.soundtq.co.nz) will be able to help you out. SC

RF Explorer

In a world filled with wireless radio signals, there is a real need to quickly search for clear bands, find interference and measure signals. Wireless microphones, video links, phone networks, Wi-Fi, ZigBee, Bluetooth, ISM bands, remote control hobbies and more all clutter the airwaves...

Introducing The RF Explorer

- RF Spectrum Analyser
- Affordable
- Handheld and portable
- Capture and analyse data
- Long-life rechargeable battery
- Upgradeable and updateable
- Free downloadable Mac and Windows software

Available in various frequency versions, the RF Explorer is a useful addition to your toolbox.

The various models and their frequency coverage:

www.soundlabsgroup.com.au

Sydney: (02) 4627-8766
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Adding Voltage and Current to the Bits'n'Pieces Battery

There are three easy ways to add voltage and current meters to our battery charger. One is relatively expensive, one is dirt cheap and one is in the middle. Let's look at these in turn:

(a) Using Mechanical (Moving Coil) Panel Meters

This is arguably the easiest way to go because you can buy panel meters already set up to read exactly what you want. For example, the Altronics Q0421A panel meter reads 0-20A "straight out of the box", while their Q0523A model reads 0-20V. The other big advantage of these panel meters is that they don't require power to operate so that also simplifies things somewhat.

All you need to do with these meters is cut suitable holes in the charger case, mount the meters and then connect the ammeter in series with the output and the voltmeter in parallel with the output.

Bingo – simple. But this is the most expensive way to go and it's not all that accurate, simply because the meter scale only lets you read to about the nearest amp or volt. In many cases this might be all you need but sometimes, you want more accuracy than that.

And unless you can snaffle a couple of suitable meters from junked equipment, you're going to be up for around $15 per meter. That's a significant proportion of what the charger without meters would cost!

When we said "suitable" meters a moment ago, you'd probably be aware that just about all meters can be set up to read whatever you want them to. The same basic meter, with an appropriate shunt (a low-value resistance in parallel) will read whatever amperes (or parts thereof) you set it up to read, or with appropriate multiplier (a much higher resistance in series with the meter), whatever voltage you want.

A typical moving coil meter without shunt or multiplier might read, say, 1mA full scale. This meter would have a resistance of 210Ω. But if you put

Meters Charger

Last month, when we put together our bits'n'pieces battery charger, we promised to show how to add meters to show both current and voltage. Sure, it's getting out of the realms of a dirt cheap charger but, what the heck . . .

by Ross Tester

another 210Ω resistor in parallel with it, it will read 2mA full scale – half the current flows through the meter, half through the shunt.

The lower value you make that resistor in parallel, the more current flows through it but the current through the meter movement (and therefore the reading) will stay in proportion.

To read high currents, the vast majority of current needs to flow through the shunt so the values of shunt resistance become very low indeed – fractions of an ohm.

It's similar with voltage: the resistance of the meter movement is still 210Ω so if you put, say, a 20kΩ resistor in series with it, the voltage will divide in the ratio of 210:20,210 and if there is 20V across both the meter and multiplier, the meter will read 20V (or very close to it).

So as you can see, if you can find a couple of old meters and (carefully!) work out what their resistance is by slowly increasing the current through them until they read full scale (also called their sensitivity), you can use Ohm's law to work out their resistance (ie, R=V/I), you can then make up your own shunts and multipliers to make the meters read what you want.

Before we finish with mechanical panel meters, you might have heard of "expanded scale" meters. These are invariably standard meters which have shunts and multipliers set up so that they read only a limited range of values – for example, 10-15V – which means that they don't start reading until the voltage exceeds 10V and it reaches maximum scale at 15V. This gives much greater accuracy as the divisions on the scale are further apart (or there are many more of them).

These little multimeters from Jaycar are so cheap you could justify using one as a dedicated panel meter. Powering on and off could be a problem – unless you use the tricky little circuit elsewhere in this issue!

(b) Using cheap DMMs

This is the lowest-cost method and for many people, it will be more than sufficient.

Elsewhere in this issue we show how to add auto power-down to cheap ($4.95) digital multimeters from Jaycar (QM1502).

That's right, the whole DMM is just $4.95!

You can set it to read what you want (eg, 20V or 10A) and measure the voltage or the current in the normal way – voltage in parallel, current in series.

At the price, you could afford to have two of these meters dedicated to read voltage and current, simply by leaving the dial set and turning the meters on when needed.

But it doesn't matter if the meters are turned on or not when using the battery charger, charging current will still flow through the shunt in the meter so it will make precious little difference and as a voltmeter, it is in parallel with the output so might as well not be there.

Unfortunately, you cannot power the multimeter from the same source as being measured but with the simple modification mentioned, the 12V battery in these cheapies should last for quite a long time.

If you got really enthusiastic, you could work out a way to mount these DMMs inside the charger case and bring the "power" pushbutton out to the case.

Incidentally, the rotary switch on a multimeter merely selects various shunts and multipliers to read amps and volts over various ranges. To measure resistance (Ohms) it uses an internal battery to push a small current through the resistor and reads that current but displays it as resistance.

To measure AC voltage or current, in the vast majority of cases the AC is rectified inside the multimeter and the resulting DC voltage or current is displayed on an "AC" scale.

(c) Using Digital Panel Meters

This is the preferred approach – it will cost more than using cheap DMMs but not as much as using mechanical meters.

In our case, we are using a couple of Oatley Electronics' 3.5-digit Digital Panel Meters (DPM1). One is set up to read volts, the other amps – just the same as the panel meters above.

However, these digital panel meters do need power and, once again, you cannot simply power them from the device being measured. But the power they need to operate is "flea power" –

One of these moving-coil meters reads 0-20V, the other 0-50μA. But they are exactly the same meter movement – to read voltage, you add a series multiplier; for current, you add a parallel shunt. Obviously scales are changed to reflect the different measurements.

Now we're talking! These $9.95 Digital Panel Meters from Oatley Electronics (Cat no DPM1) can be set up to read current or voltage – which is exactly what we're after.

just a couple of milliamps. If you add Oatley's K-265 Interface Kit (K265) it will supply all the power you need from the battery charger itself.

3.5 or 4 digits?

Before we get into it, though, we can already hear the question: 3.5 digit? I can see four digits!

It's long been a source of confusion – but the explanation is pretty simple. It's more expensive to produce a meter which reads 9999 (a 4-digit display), so many are made to read 1999 instead.

Therefore, a 3.5-digit display can show any value up to 1.999 (or 19.99, 199.9, 1999). In our case, we want it to display up to 20A and 20V – well, it can just about do that – it can never *quite* get there (it's 1mV or 1mA short!).

OK, so how do you use them?

Basically, using a digital panel meter is very similar to using a mechanical panel meter, as detailed above. The instructions supplied with the meter show how to set it up as a voltmeter, with a series multiplier, or an ammeter, with a parallel shunt (now where have we heard those terms before?).

Building the interface board

This is simply a matter of following the diagrams supplied with the kit and on the PCB component overlay. Just a couple of tips: three miniature transformers are supplied; it doesn't matter which one goes where.

However, you will find there are three pins on one side and two on the other – which determines which orientation they have! And before soldering the PCB-mounting terminal blocks in, slide them together so they link. Finally, don't mix up the four 1N4148 small signal diodes with the 9.1V zener – the circuit won't work if you do – and also note that the zener mounts in the opposite direction to the other four diodes.

One other point to note: the overlay on the PCB was different to that supplied in the instructions – the overlay is correct, with a 2k trimpot (VR3) instead of a fixed resistor (R6 – 390Ω).

Once completed and before the interface is connected to the digital panel meters, though, we need to adjust the output voltage (using VR3) to get 9V.

Using a 12V battery, connect power to the interface board and adjust VR3 to get as close as you can to 9V at the output "V" and "I" DPM terminals (they should be identical). Once done, disconnect the battery and put the interface board aside until you're ready to assemble everything.

Preparing the box

From here on, we are assuming that you are using the preferred approach.

The first task is to determine where you want to mount the DPMs. The main thing to remember is to keep them away from the "bitey bits" on the left side of the box – we chose a spot on the top right.

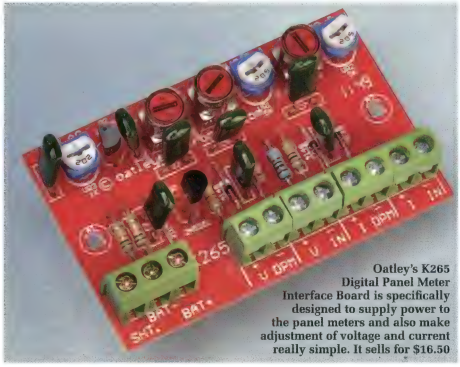
Mark the positions of your meters remembering that there is an escutcheon which is larger than the meter itself. There should be around 20mm between the meters if mounting them side-by-side.

Mark the two cutouts, which should be 50 x 25mm, in your chosen positions, and cut them out.

Whether you use the tried and true method of drilling a lot of small holes and cutting out the panel (filing it smooth), drilling a larger hole and nibbling out the panel or perhaps using a metal blade in a jigsaw, make sure that you don't get any swarf in the case. In fact, it's a good idea to open the case right out – that means your blade or drill can't do any damage either.

Mark the four holes for each of the mounting screws (attached to the escutcheon) and drill them out to 3mm. These holes are centred around the display, 60mm wide and 24mm deep.

Remove the nuts from the displays and separate the back halves from their escutcheons. Make sure the four bolts attached to the escutcheons fit easily through the mounting holes and that



Oatley's K265 Digital Panel Meter Interface Board is specifically designed to supply power to the panel meters and also make adjustment of voltage and current really simple. It sells for $16.50

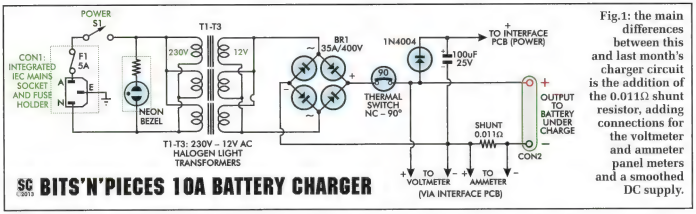


Fig.1: the main differences between this and last month's charger circuit is the addition of the 0.011Ω shunt resistor, adding connections for the voltmeter and ammeter panel meters and a smoothed DC supply.

the escutcheons cover the edges of the cutouts.

Before we mount the DPMs we need to modify them slightly to act as the 0-20V and 0-20A meters.

Modifying the DPMs

As supplied, the DPMs are set up to read 200mV (well, actually 199.9mV). To make them read 20V we need to change the multiplier and move the decimal point.

Rather than try to disassemble the panel meter PCB (which is not easy) and reassemble it (which is almost impossible!) provision is made on the interface board.

You would have earlier (during construction of the interface board) selected a 1MΩ resistor (R1) so the DPM would read 20V; all you need do is connect the DPM to the interface board (both power and voltage input), connect a known voltage source of, say, 12-20V DC to the BAT+ and BAT- terminals of the interface board and adjust the "V CAL" trimpot (VR1) to that voltage.

For example, you could use a 12V SLA battery and your digital multimeter to get the known voltage.

Changing the decimal point is not quite so simple. It is wired to suit a "199.9" reading; we want it to suit a "19.99" reading. Theoretically, that's just a matter of changing a link on the PCB from P3 to P2 – but as we said earlier, disassembling the PCB to get at the P3 link is not a good idea.

Instead, we are suggesting you carefully cut a track on the PCB and solder a link between that cut track and the right-hand pair of P2 pads – the photo below shows the detail.

To solder to a solder-masked track, carefully scrape some of the green mask off the track to reveal bright copper and equally carefully solder to that. Be careful – it doesn't take much heat to lift thin tracks.

The current meter needs to have the same decimal point modification as we want it to read up to 19.99A. Once again, the interface board is set up to allow it to read this with a suitable shunt connected.

The shunt is actually two parallel-connected 1.5m lengths of resistance wire (supplied in the interface kit). A single length of this wire has a resistance of 0.0146 ohms per metre, so 2x 1.5m lengths in parallel will have a resistance of 0.011Ω.

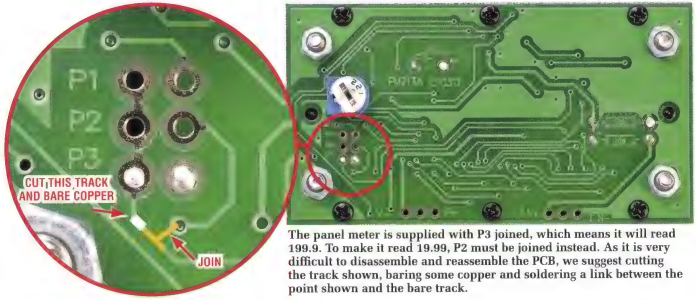
If reading 20A, this will result in a voltage drop of 0.22V. While this is slightly too high (it should be 0.199V) this error can be corrected via the use of the "I CAL" trimpot, VR2.

Connecting the shunt

The shunt is simply wired in series with the charger output. You need to break the connection between the bridge rectifier and the negative output terminal and wire the shunt in its place.

A pair of much thinner wires (as thin as you like!) connect from each end of the shunt to the "SHT" and "BAT-" terminals on the interface board.

We wound the shunt into a pretty



The panel meter is supplied with P3 joined, which means it will read 199.9. To make it read 19.99, P2 must be joined instead. As it is very difficult to disassemble and reassemble the PCB, we suggest cutting the track shown, baring some copper and soldering a link between the point shown and the bare track.

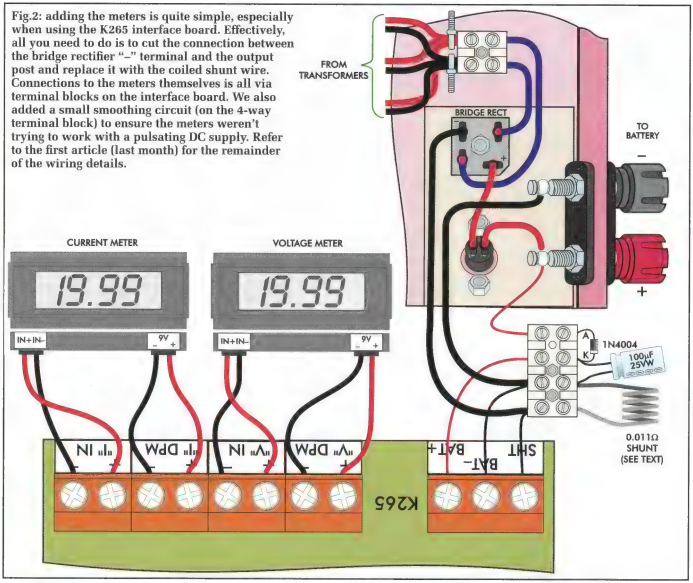


Fig.2: adding the meters is quite simple, especially when using the K265 interface board. Effectively, all you need to do is to cut the connection between the bridge rectifier "–" terminal and the output post and replace it with the coiled shunt wire. Connections to the meters themselves is all via terminal blocks on the interface board. We also added a small smoothing circuit (on the 4-way terminal block) to ensure the meters weren't trying to work with a pulsating DC supply. Refer to the first article (last month) for the remainder of the wiring details.

small coil and placed it near the output terminals. A two-way terminal block is provided in the kit but we replaced this with a much larger 4-way block – this is much easier to connect to as the shunt wires (and the output wires) are quite thick and securing them in the small terminal block is not the easiest thing in the world.

Besides, we wanted another two terminals for some more components.

Connecting the multiplier

It's already done for you – on the interface board!

Connecting power from the charger

As you would realise, the output from the bridge rectifier is pulsating DC and there is very little in the way of smoothing on the interface board.

To make use of the charger output, we used a diode in series (to isolate the supply from the charger output) and a small electrolytic capacitor to give a smooth supply for the interface.

Again, this can be placed wherever it will fit – the same terminal block can hold these two components.

Parts List – Adding Meters to the Bits'n'Pieces Battery Charger

- 2 3.5-digit panel meters (eg, Oatley Electronics DPM1)
- 1 DPM Interface Kit (Oatley Electronics K265)
- 1 100µF 25V electrolytic capacitor
- 1 1N4004 power diode
- 1 4-way large terminal block
- Hookup wire
- Nuts, screws and washers as required.

Connecting the modules

These are pretty-much self explanatory. You have four terminal blocks on the interface board – the ones labelled "V" are for the voltmeter and the ones labelled "I" are for the current meter. Fig.2 shows the connections – "V" & "I" DPM supply power; + to + and – to – respectively.

"V IN" and "I IN" are the connections for the measurement terminals (again, + to + and – to –).

The only slight wrinkle here is that the solder pads on the modules are very small. Be careful soldering to them (ignore the centre terminal in all cases).

It will probably be easier if you connect the modules and shunt before screwing everything into place. Don't forget, the wire between the interface

(Above): here's how we "wound" the shunt resistor. It consists of two 1.5m lengths of insulated resistance wire, wound together. Final resistance is 0.011Ω. Actual number of turns is immaterial – just make it as small as practical! The 2-way terminal block (which comes with the kit) was later replaced with a much larger 4-way block, which also connects the power supply components.

(Right): the new components to drive the panel meters are all mounted on the right side of the case, as seen here. Ensure there is plenty of clearance between the meters and interface board/terminal block when the lid is closed and that there is enough wire to avoid them being stretched.

and panel meters doesn't have to be at all thick. We used rainbow cable.

The only thick cables needed are those required to pass the battery charging current – most of what you need should already be in place from the "meterless" version of last month. In fact, the only extra length of heavy duty cable we needed was to connect the terminal block (shunt connection) back to the negative output terminal.

Use cable ties to ensure all cables are secured and won't come adrift, especially when the case lid is opened.

Where do you mount the interface?

Wherever you can! There should be enough space for it (and the terminal blocks for both shunt and diode/electro) near the rectifier. You might have to move things around a little bit but there should be tons of room.

We mounted ours on the end of the case and stood it off the surface by the thickness of one nut and washer (see photo above).

Connect everything up, check your wiring twice and you're ready for the smoke test. If you don't get any, you've passed!

To finish off, mark the case with a couple of labels showing which is the voltmeter and which is the ammeter.

Got an extra transformer?

Not long after the April issue went on sale we received a note from one of our readers, Charles Tivendale, who told us that he had made a similar charger some years ago but he used an extra transformer to give improved performance.

It wasn't, as you might expect, simply in parallel with the other transformers. He used the fourth transformer to boost the primary voltage slightly to the other three, thus giving slightly higher secondary voltages.

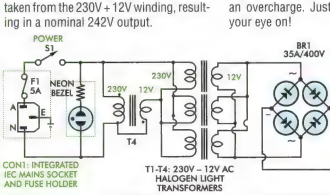
This was done as shown in the circuit below, with the secondary winding of one transformer connected in series with the primary and used as an auto-transformer. In other words, the 230V mains voltage was applied to the primary with the output taken from the 230V + 12V winding, resulting in a nominal 242V output.

This slightly higher voltage was then applied to the primaries of the other transformers, resulting in a slightly higher output voltage to the bridge rectifier.

Naturally, this gave more output from the charger – not a huge amount but enough to make the whole exercise worthwhile (especially if the transformer cost you nothing!).

The phasing of the new transformer windings is important – if you connect them up incorrectly, you'll get less than 220V out. If this happens, simply reverse the connections to the 12V winding.

One point to note: as there is no current control on this simple charger, if the battery is fully charged (ie, it's gassing) the extra voltage might be enough to cause an overcharge. Just something to keep your eye on! SC



Here's how to add an extra transformer (in auto-transformer mode) to give a slightly higher output voltage.

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Looking for a specialised component to build that latest and greatest *Silicon Chip* project? Maybe it's the PCB you're after. Or a pre-programmed micro. Or some other hard-to-get 'bit'. The chances are they are available direct from the ***Silicon Chip* ONLINESHOP.**

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CHAMP: SINGLE CHIP AUDIO AMPLIFIER	FEB 1994	01102941	$5.00
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HEAT CONTROLLER	JULY 1998	10307981	**$10.00**
MINIMITTER FM STEREO TRANSMITTER	APR 2001	06104011	$25.00
MICROMITTER FM STEREO TRANSMITTER	DEC 2002	06112021	$10.00
SMART SLAVE FLASH TRIGGER	JUL 2003	13107031	$10.00
12AX7 VALVE AUDIO PREAMPLIFIER	NOV 2003	01111031	$25.00
POOR MAN'S METAL LOCATOR	MAY 2004	04105041	$10.00
BALANCED MICROPHONE PREAMP	AUG 2004	01108041	$25.00
LITTLE JIM AM TRANSMITTER	JAN 2005	06101062	$25.00
POCKET TENS UNIT	JAN 2006	11101061	$25.00
STUDIO SERIES RC MODULE	APRIL 2006	01104061	$25.00
ULTRASONIC EAVESDROPPER	AUG 2006	01206061	$25.00
RIAA PREAMPLIFIER	AUG 2006	01108061	$25.00
GPS FREQUENCY REFERENCE (A) (IMPROVED)	MAR 2007	04103073	**$30.00**
GPS FREQUENCY REFERENCE DISPLAY (B)	MAR 2007	04103072	**$20.00**
KNOCK DETECTOR	JUNE 2007	05108071	$25.00
SPEAKER PROTECTION AND MUTING MODULE	JULY 2007	01207071	$20.00
CDI MODULE SMALL PETROL MOTORS	MAY 2008	05105081	$15.00
LED/LAMP FLASHER	SEP 2008	11009081	$10.00
12V SPEED CONTROLLER/DIMMER	*(Use Hot Wire Cutter PCB from Dec 2010 (10112101))*		
USB-SENSING MAINS POWER SWITCH	JAN 2009	10101091	$45.00
DIGITAL AUDIO MILL/VOLTMETER	MAR 2009	04103091	$35.00
INTELLIGENT REMOTE-CONTROLLED DIMMER	APR 2009	10104091	$10.00
INPUT ATTENUATOR FOR DIG. AUDIO M'VOLTMETER	MAY 2009	04205091	$10.00
6-DIGIT GPS CLOCK	MAY 2009	04105091	$35.00
6-DIGIT GPS CLOCK DRIVER	JUNE 2009	07106091	$25.00
UHF ROLLING CODE TX	AUG 2009	15008091	$10.00
UHF ROLLING CODE RECEIVER	AUG 2009	15008092	$45.00
6-DIGIT GPS CLOCK AUTODIM ADD-ON	SEPT 2009	04208091	$10.00
STEREO DAC BALANCED OUTPUT BOARD	JAN 2010	01101101	$25.00
DIGITAL INSULATION METER	JUN 2010	04106101	$25.00
ELECTROLYTIC CAPACITOR REFORMER	AUG 2010	04108101	$55.00
ULTRASONIC ANTI-FOULING FOR BOATS	SEP 2010	04109101	$25.00
HEARING LOOP RECEIVER	SEP 2010	01209101	$25.00
S/PDIF/COAX TO TOSLINK CONVERTER	OCT 2010	01210101	$10.00
TOSLINK TO S/PDIF/COAX CONVERTER	OCT 2010	01210102	$10.00
DIGITAL LIGHTING CONTROLLER SLAVE UNIT	OCT 2010	16110102	$45.00
HEARING LOOP TESTER/LEVEL METER	NOV 2010	01111101	$25.00
UNIVERSAL USB DATA LOGGER	DEC 2010	04112101	$25.00
HOT WIRE CUTTER CONTROLLER	DEC 2010	18112101	**$10.00**
433MHZ SIMPLER	JAN 2011	06101111	$10.00
CRANIAL ELECTRICAL STIMULATION	JAN 2011	99101111	$30.00
HEARING LOOP SIGNAL CONDITIONER	JAN 2011	01101111	$30.00
LED DAZZLER	FEB 2011	16102111	$25.00
12/24V 3-STAGE MPPT SOLAR CHARGER	FEB 2011	14102111	$15.00
SIMPLE CHEAP 433MHZ LOCATOR	FEB 2011	06102111	$5.00
THE MAXIMITE	MAR 2011	06103111	$25.00
UNIVERSAL VOLTAGE REGULATOR	MAR 2011	18103111	$15.00
12V 20-120W SOLAR PANEL SIMULATOR	MAR 2011	04103111	$25.00
MICROPHONE BOOK LOOP COUPLER	MAR 2011	01209101	$25.00
PORTABLE STEREO HEADPHONE AMP	APRIL 2011	01104111	$25.00
CHEAP 100V SPEAKER/LINE CHECKER	APRIL 2011	04104111	**$10.00**
PROJECTOR SPEED CONTROLLER	APRIL 2011	13104111	$10.00
SPORTSYNC AUDIO DELAY	MAY 2011	01105111	$30.00
100W DC-DC CONVERTER	MAY 2011	11105111	$25.00
PHONE LINE POLARITY CHECKER	MAY 2011	12105111	$10.00
20A 12/24V DC MOTOR SPEED CONTROLLER MK2	JUNE 2011	11106111	$25.00
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USB BREAKOUT BOX	JUNE 2011	24106111	$10.00
ULTRA-LD MK3 200W AMP MODULE	JULY 2011	01107111	$25.00
PORTABLE LIGHTNING DETECTOR	JULY 2011	04107111	$25.00
RUDDER INDICATOR FOR POWER BOATS (4 PCBs)	JULY 2011	20107111-4	$80 per set
VOX	JULY 2011	01207111	$25.00
ELECTRONIC STETHOSCOPE	AUG 2011	01108111	$25.00
DIGITAL SPIRIT LEVEL/INCLINOMETER	AUG 2011	04108111	$15.00
ULTRASONIC WATER TANK METER	SEP 2011	04109111	$25.00
ULTRA-LD MK2 AMPLIFIER UPGRADE	SEP 2011	01209111	$5.00
ULTRA-LD MK3 AMPLIFIER POWER SUPPLY	SEP 2011	01109111	$25.00

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	PCB CODE:	Price:
HIFI STEREO HEADPHONE AMPLIFIER	SEP 2011	01309111	**$30.00**
GPS FREQUENCY REFERENCE (IMPROVED)	SEP 2011	04103073	**$30.00**
DIGITAL LIGHTING CONTROLLER LED SLAVE	OCT 2011	16110111	$30.00
USB MIDIMATE	OCT 2011	23110111	$30.00
QUIZZICAL QUIZ GAME	OCT 2011	08110111	$30.00
ULTRA-LD MK3 PREAMP'S REMOTE VOL CONTROL	NOV 2011	01111111	**$30.00**
ULTRA-LD MK3 INPUT SWITCHING MODULE	NOV 2011	01111112	$25.00
ULTRA-LD MK3 SWITCH MODULE	NOV 2011	01111113	$10.00
ZENER DIODE TESTER	NOV 2011	04111111	$20.00
MINIMAXIMITE	NOV 2011	07111111	$10.00
ADJUSTABLE REGULATED POWER SUPPLY	DEC 2011	18112111	$5.00
DIGITAL AUDIO DELAY	DEC 2011	01212111	$30.00
DIGITAL AUDIO DELAY Front & Rear Panels	DEC 2011	01212111P2/3	$20 per set
AM FASKO	JAN 2012	01101121	$10.00
STEREO AUDIO COMPRESSOR	JAN 2012	01201121	$30.00
STEREO AUDIO COMPRESSOR FRONT & REAR PANELS	JAN 2012	01201121P1/2	$20.00
3-INPUT AUDIO SELECTOR (SET OF 2 BOARDS)	JAN 2012	01101121/2	$30 per set
CRYSTAL DAC	FEB 2012	01102121	$20.00
SWITCHING REGULATOR	FEB 2012	18102121	$5.00
SEMTEST LOWER BOARD	MAR 2012	04103121	$40.00
SEMTEST UPPER BOARD	MAR 2012	04103122	$40.00
SEMTEST FRONT PANEL	MAR 2012	04103123	$75.00
INTERPLANETARY VOICE	MAR 2012	08102121	$10.00
12/24V 3-STAGE MPPT SOLAR CHARGER REV.A	MAR 2012	14102112	$20.00
SOFT START SUPPRESSOR	APR 2012	10104121	$10.00
RESISTANCE DECADE BOX	APR 2012	04104121	$20.00
RESISTANCE DECADE BOX PANEL/LID	APR 2012	04104122	$20.00
1.5kW INDUCTION MOTOR SPEED CONTROLLER (New V2 PCB)	APR 2012 (DEC) 2012	10105121	$35.00
HIGH TEMPERATURE THERMOMETER MAIN PCB	MAY 2012	21105121	$30.00
HIGH TEMPERATURE THERMOMETER Front & Rear Panels	MAY 2012	21105122/3	$20 per set
MIX-IT! 4 CHANNEL MIXER	JUNE 2012	01106121	$20.00
PIC/AVR PROGRAMMING ADAPTOR BOARD	JUNE 2012	24105121	$30.00
CRAZY CRICKET/FREAKY FROG	JUNE 2012	08106121	$15.00
CAPACITANCE DECADE BOX	JULY 2012	04106121	$20.00
CAPACITANCE DECADE BOX PANEL/LID	JULY 2012	04106122	$20.00
WIDEBAND OXYGEN CONTROLLER MK2	JULY 2012	05106121	$20.00
WIDEBAND OXYGEN CONTROLLER MK2 DISPLAY BOARD	JULY 2012	05106122	$10.00
SOFT STARTER FOR POWER TOOLS	JULY 2012	10107121	$10.00
DRIVEWAY SENTRY MK2	AUG 2012	03107121	$20.00
MAINS TIMER	AUG 2012	10108121	$10.00
CURRENT ADAPTOR FOR SCOPES AND DMMS	AUG 2012	04108121	$20.00
USB VIRTUAL INSTRUMENT INTERFACE	SEPT 2012	24109121	$30.00
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CLASSIC-D 2 CHANNEL SPEAKER PROTECTOR	NOV 2012	01108122	$10.00
HIGH ENERGY ELECTRONIC IGNITION SYSTEM	DEC 2012	05110121	$10.00
USB POWER MONITOR	DEC 2012	04109121	$10.00
1.5kW INDUCTION MOTOR SPEED CONTROLLER (NEW V2 PCB)	DEC 2012	10105122	$35.00
THE CHAMPION PREAMP and 7W AUDIO AMP (one PCB)	JAN 2013	01109121/2	$10.00
GARBAGE/RECYCLING BIN REMINDER	JAN 2013	19111121	$10.00
2.5GHz DIGITAL FREQUENCY METER – MAIN BOARD	JAN 2013	04111121	$35.00
2.5GHz DIGITAL FREQUENCY METER – DISPLAY BOARD	JAN 2013	04111122	$15.00
2.5GHz DIGITAL FREQUENCY METER – FRONT PANEL	JAN 2013	04111123	$45.00
SEISMOGRAPH MK2	FEB 2013	21102131	$20.00
MOBILE PHONE RING EXTENDER	FEB 2013	12110121	$10.00
GPS 1PPS TIMEBASE	FEB 2013	04103131	$10.00
LED TORCH DRIVER	MAR 2013	16102131	$5.00
CLASSIC DAC MAIN PCB	APR 2013	01102131	$40.00
CLASSIC DAC FRONT & REAR PANEL PCBs	APR 2013	01102132/3	$30.00
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LED LADYBIRD	APR 2013	08103131	$5.00
CLASSIC-D 12V to ±35V DC/DC Converter	MAY 2013	11104131	$15.00
DO NOT DISTURB	MAY 2013	12104131	$10.00

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NOTE: Those listings are for the PCB only – *not a full kit.* If you want a kit, contact the kit suppliers advertising in this issue.

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PIC12F675-I/PT	Do Not Disturb (May10)
PIC16F1587-I/P	Wideband Oxygen Sensor (Jun-Jul12)
PIC16F88-E/P	Projector Speed (Apr11), Vox (Jun11), Ultrasonic Water Tank Level (Sep11), Quizzical (Oct11) Ultra LD Preamp (Nov11) Hi Energy Ignition (Nov/Dec12)
PIC16LF88-I/P	Garbage Reminder (Jan13)
PIC16LF88-I/SO	LED Ladybird (Apr13)
PIC16F877A-I/P	6-Digit GPS Clock (May-Jun09), Lab Digital Pot (Jul10) Semtest (Feb-May12)
PIC18F2550-I/SP	Batt Capacity Meter (Jun09), Intelligent Fan Controller (Jul10)
PIC18F45K80	USB Power Monitor (Dec12)
PIC18F4550-I/P	GPS Car Computer (Jan10), GPS Boat Computer (Oct10)
PIC18F14K50	USB MIDIMate (Oct11)
PIC18F27J53-I/SP	USB Data Logger (Dec10-Feb11)
PIC18LF14K22	Digital Spirit Level (Aug11), G-Force Meter (Nov11)
PIC18F1320-I/SO	Intelligent Dimmer (Apr09)
PIC32MX795F512H-80L/PT	Maximite (Mar11), miniMaximite (Nov11), Colour Maximite (Sept/Oct12)
dsPIC33FJ128GP802-I/SP	Digital Audio Signal Generator (Mar-May10), Digital Lighting Controller (Oct-Dec10), SportSync (May11), Digital Audio Delay (Dec11) Level (Sep11) Quizzical (Oct11), Ultra-LD Preamp (Nov11), LED Musicolor (Nov12)
dsPIC33FJ128GP306-I/PT	CLASSIC DAC (Feb-May 13)
ATTiny861	VVA Thermometer/Thermostat (Mar10), Rudder Position Indicator (Jul11)
ATTiny2313	Remote-Controlled Timer (Aug10)
ATMega48	Stereo DAC (Sep-Nov09)

When ordering, be sure to nominate BOTH the micro required and the project for which it must be programmed.

Other items currently in the OnLineShop:

P&P – $10 Per order within Australia.

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CLASSIC DAC SHORT FORM KIT (Includes three hard-to-get SMD ICs: CS8416-CZZ, CS4398-CZZ and PLL1708DBQ plus an accurate 27MHz crystal and ten 3mm blue LEDs with diffused lenses	Feb-May13)	$45.00
ISL9V5036P3 IGBT to suit High Energy Electronic Ignition	NOV/DEC 2012	$10.00
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JST CONNECTOR LEAD 2-WAY	JAN 2012	$3.45
RADIO & HOBBIES ON DVD-ROM (Needs PC to play!)	n/a	$82.00

Prices include GST and are valid only for month of publication of these lists; thereafter are subject to change without notice. *Note: P&P is extra ($10 per order in Australia).

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Vintage Radio

By Associate Professor Graham Parslow

Rescued from a farm: a rare 1948 model 766 Breville radio

Sixty-five years of abuse and abject neglect made restoring this 1948 Breville 766 radio a real challenge. It's an interesting 6-valve battery-powered set designed specifically for use in rural areas.

The old Breville 766 was in quite poor condition when purchased, having spent most of its life in a chicken coop.

HOW DID A 1948 6-valve Breville 766 radio get to spend most of its 65 years in a farm chicken coop, accumulating muck? I can only speculate that the farmer wanted to listen to the radio while feeding the chooks. But speculation aside, this is an interesting radio with interesting historical connections to the Australian radio industry.

These days, the Breville brand-name is one that most people only associate with electrical gadgets and kitchenware but it was not always so. The Breville company dates back to 1932 when its two founders, Bill O'Brien and Harry Norville, created the brand-name by combining their names. The company started off making valve radios as its main product and the Australian Official Radio Service Manuals (AORSM) list numerous Breville models between 1937 and 1955.

The advertisement reproduced later in this article is from the 1938 AORSM and shows that at the time, Breville specialised in high-performance radios for farms. World War 2 subsequently stopped all domestic radio manufacture and so Breville diversified into manufacturing mine detectors for the military during the war years.

After the war, Breville resumed making radios and also began manufacturing small appliances (hence the brand that we know today). Radios were discontinued under the Breville name after 1955 and were instead made under the Precedent brand-name, along with stereograms and TV sets. The Precedent business was subsequently sold in 1968, leaving Breville to concentrate on appliance manufacture.

The reason that Breville remains well known is due to the development of its novel sandwich toaster in 1974, a product that became a global marketing success. Another success from 1977 was Australia's first food processor, the Breville "Kitchen Wizz".

32V systems

Following European settlement, Australia made its original fortune from sheep and wheat, helped by the occasional gold rush. As a result, the Australian population was highly rural until World War 2 when many new manufacturing jobs resulted in a drift in the population to urban centres. Even so, during the 1950s, a large part of the population remained in rural centres, many of which lacked mains electricity.

By coincidence the Breville model

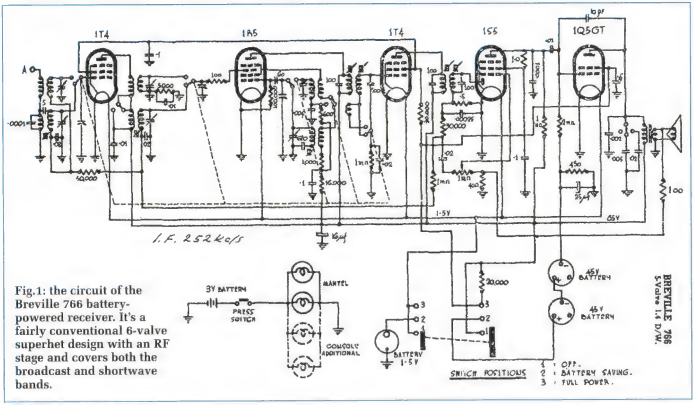


Fig.1: the circuit of the Breville 766 battery-powered receiver. It's a fairly conventional 6-valve superhet design with an RF stage and covers both the broadcast and shortwave bands.

766 featured here shares the author's birth year of 1948. The author grew up 220km from Adelaide in a community where the farms largely ran on "freelight", a standard 32V system using lead-acid batteries charged by wind-powered generators.

The small town that I lived in was better off, with a diesel generator that provided 240VAC between 6am and midnight. This ended in 1956 when mains power was brought to the area.

In fact, 32V systems were common in rural Australia and many farms were quite some distance from radio transmitters. As a result, many specialised farm radios were made and they had to be quite sensitive in order to receive weak signals. They also had to be frugal when it came to power consumption, so they could be powered using (expensive) single-use batteries or by batteries and mechanical vibrator circuitry to produce the necessary HT rail.

Unfortunately, vibrators were noisy in operation and their constant buzz was rarely welcome.

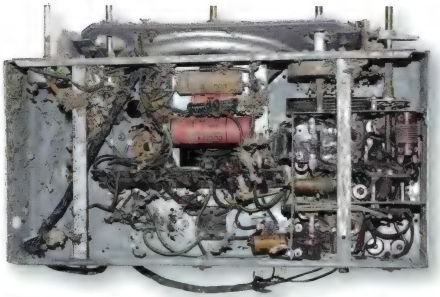
The 6-series valves (indicating 6.3V filaments) of the 1930s onwards had a power consumption of 40-60W in a radio designed to produce an audio output of around 1W. By contrast, the Breville 766 uses compact 1-series valves (nominal 1.4V filaments) and consumes less than 2W for around 300mW of audio.

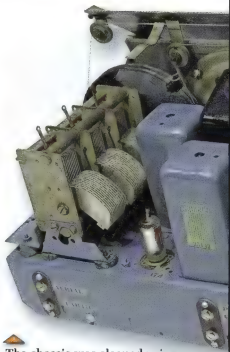
In the restored Breville radio featured here, the 90V (battery-powered) HT rail draws 15mA, while the 1.5V filament supply draws 320mA. Selecting the "economy" position using the Battery Switch on the front panel reduces the HT consumption to 12mA by inserting a series resistor but this has no affect on the filament current drawn from the 1.5V battery.

Circuit details

The circuit of the 766 is a fairly standard 6-valve superheterodyne design with an RF amplifier stage – a configuration easily determined due to the use of a 3-section tuning gang. Fig.1 shows the details.

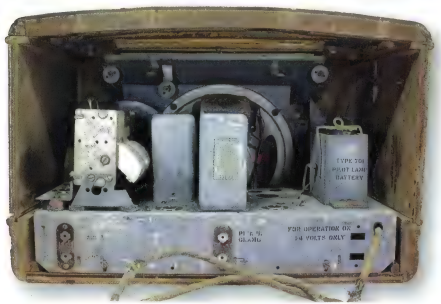
This view shows the fully-restored receiver. Repairing the cabinet was a major part of the restoration.





Above & below: these two photos show the poor condition of the set prior to restoration. Note the amount of chicken droppings that had found their way under the chassis and that's after the loose material had fallen away! The view below shows the set after blowing away the gunk with compressed air.

The chassis was cleaned using a paint brush, mineral turpentine and WD-40.



The RF amplifier stage is based on a 1T4 valve, with a 1R5 as the mixer-oscillator and another 1T4 as an IF (intermediate frequency) amplifier. Interestingly, the IF for this model is 252kHz, not the more common 455kHz. This makes the set more sensitive and selective when it comes to receiving longer wavelength stations in the broadcast band.

A 1S5 diode-pentode serves as the detector and as an audio preamplifier. This in turn drives a 1Q5 audio output stage. The 1Q5 valve is somewhat odd in appearance, being housed in a GT glass envelope that's sized somewhere between the "new" compact size of the other valves used in the set and the older-style "full-size" valves.

An interesting feature is that the dial lights are only illuminated when a side-mounted pushbutton switch connects a 3V bicycle battery into circuit with the globes. This was obviously a power-saving measure to conserve the battery. Fortunately, this radio came with an original Eveready battery still mounted in its "clip-down" battery box on the top of the chassis.

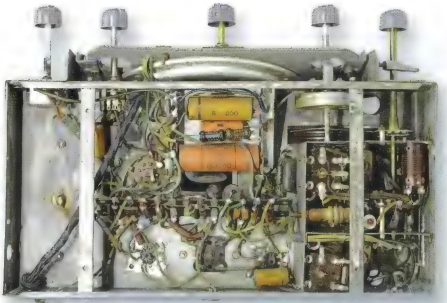
No chickening out

The model 766 includes a number of high-quality features, such as a sturdy chassis, rugged IF coils, a shortwave band and a Magnavox 8-inch speaker. The restored radio has excellent sound quality, a remarkable outcome considering the state the set was in when I purchased it.

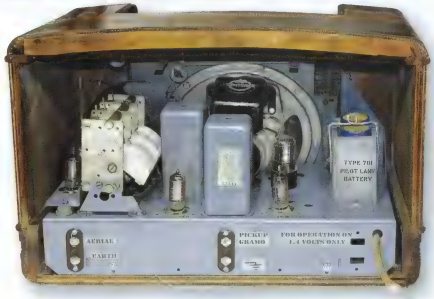
Regular SILICON CHIP readers may recall the Vintage Radio article in September 2012 which described how the author acquired a collection of poorly-preserved radios from rural Victoria. As stated in that article, "the radios were in appalling condition and, after a quiet moment of reflection on the value of my purchase, some of the despondency was relieved by simply getting a hose and washing the chicken droppings off the Breville".

In practice, there are a number of reasons why hosing down a plywood radio from the 1940s is a bad idea, including possible delamination of the ply and staining. However, given the condition of the set, there really seemed to be no other option at the time. As it turned out, I was luckier than I deserved to be and the old Breville's cabinet remained reasonably intact.

That hasty hosing meant that there are no photographs to show what the set was initially like on the outside. However, the chicken and rodent droppings that remained trapped under the chassis give an idea of the conditions that the radio had endured (see photo). The only way for chicken droppings to find their way under the chassis was via a gap behind the speaker but even so, the underside was fairly



These two photos show the underside of the chassis and the rear inside view after restoration. The chassis scrubbed up well and despite the years of neglect, very few parts needed to be replaced.



solidly packed. Because the amount of trapped debris was unexpected, the accompanying photograph only shows what remained attached to the chassis after the loose material had fallen away.

Restoration

Step 1 in the restoration was to use a compressor to blow away most of the contamination. This was followed by contact cleaning using a paint brush and liberal amounts of turpentine. Turpentine is a non-conductive solvent that evaporates completely, a process that was sped up with a few blasts from an air compressor.

Once the chassis was clean, a few judicious squirts of WD-40 were applied to lubricate the volume pot, the tuning-gang bearings and the Oak rotary switches. A few squirts of WD-40 were also applied to give hard-surface components a final clean and to add lustre to their appearance.

In fact, I discovered WD-40's excellent cleaning/shining properties by accident on a previous restoration. I would have discovered it sooner if I had read the blurb on side of the can. It lists this as being among the many virtues of the fish-oil extract in this product.

After cleaning, the chassis of the old Breville 766 looked like it had been miraculously transformed. What's more, it was in such good condition that it looked like the radio could even be quickly made to work.

The chassis was missing its 1R5 mixer-oscillator valve so I cannibalised one from another radio. The next job was to restore the dial-tuning mechanism to working order. It was missing some parts, so I scrounged a replacement dial-pointer plus a tensioning spring from the junk box and installed a new dial cord. It all worked quite well, with the smooth feel that comes when a flywheel is part of the system.

After replacing the five missing knobs (also scrounged from my junk box) and an antenna, it was time to power the old valve radio up and see if it worked. First, a bench power supply set to deliver 1.5V was connected to the valve filaments and the five valves quickly settled down to draw 320mA. A separate bench supply was then connected to the HT rail and slowly ramped up 90V.

During this process, the HT current was monitored to ensure that it didn't rise unduly and perhaps cause a faulty part to explode (it has only happened to me once but once is enough). In this case, there were no explosions and the current appeared to be normal. However, there was no response from the radio, so I twiddled the tuning.

Initially, nothing happened and thoughts of "where do I begin" began forming. But then, after a few minutes, the radio suddenly started "crackling". This is a useful sign when it comes to troubleshooting because it means

Another view of the fully-restored radio. The missing cabinet veneer was repaired using car epoxy filler.

that the loudspeaker and output transformer are probably working.

Further adjustment of the tuning then brought in stations. This was another case of the HT electrolytics reforming under voltage and resuming their normal function. In the end, no further parts needed replacing and the tuning was good, without any need for adjustment (or alignment).

Having established that it worked OK, the radio was then fitted with batteries and now runs exclusively on battery power. This gives it an almost instantaneous output after switch on, unlike most valve radios that need warm-up time (mainly due to the fact that the rectifier valve has to warm up and bring up the HT rail).

Restoring the cabinet

Getting the radio working now gave me the motivation to continue restoring the cabinet. The first step here was to use paint stripper to remove all vestiges of the original lacquer finish. The case was in two pieces (top and bottom) and all joints were in poor condition due to the failure of the animal glue originally used in 1948.

In those days, carpentry shops had a continuous hot-glue pot that was used as needed. By contrast, for this restoration, modern PVA glue was used for all joints and lots of clamps were applied to keep it together while the glue dried.

Re-gluing the top veneer proved to be quite a challenge. Some of the top veneer was simply missing and I have learnt by experience that simply splicing in another piece of veneer always produces a result that looks wrong, regardless of the technical excellence of the job.

Although the process is not intuitive, the best way to go is to apply 2-part epoxy filler (ie, car bog) and then sand this back to a smooth finish. After applying one coat of polyurethane to the entire case, the pink filler is then painted over with three shades of brown and black to blend into the wood-grain of the cabinet.

The accompanying photographs show just how successful this process proved to be. It's certainly one of those times when you get a good feeling when a job is finished.

Apart from the woodwork, a significant amount of work was also required to restore various peripheral fixtures, including the dial plastic, the metal trim and the speaker cloth. Unfortunately, the five knobs scrounged from my junk box to get the set going didn't match and finding suitable knobs proved to be a real challenge. In the end, a set of knobs was purchased to match the cabinet styling.

It was with pride that I took the completed radio to a recent meeting of The Historical Radio Society of Australia. Powered by batteries, it stood proudly independent and functioned just as it did back in 1948. One member who specialised in collecting farm radios was particularly impressed with it. He had never seen a Breville 766 before and he told me that it was now a very rare radio.

This was a project that repaid my efforts many times over. Despite being rather underwhelmed by it when I first purchased it, it's one that I am now more than happy to have in my collection. SC

Breville Radio manufactured a range of AC, vibrator and battery-powered radios, including the Apex Console and the Acme Table Model pictured here.

ASK SILICON CHIP

Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Write to: Ask Silicon Chip, PO Box 139, Collaroy Beach, NSW 2097 or send an email to silicon@siliconchip.com.au

Small metal locator wanted

I was wondering if you have ever published a circuit for a small, hand-held metal detector that would be suitable for finding metal in recycled timber, or one that could be modified for the task. I had an incident last week where I damaged a tool whilst working on my lathe, from a piece of nail that was not visible from the outside of some old red gum. I would like to try and avoid having to spend hours regrinding the edge of an expensive tool. (N. C., Bayswater, Vic).

● We described a hand-held metal locator in the June 2009 issue which used a 7555, an LM358 and not much else but we do not have a PCB for it. However, a typical stud-finder that you can buy from your local hardware store should do much the same job.

Digital lighting controller & slave kit

I have constructed the Digital Lighting Controller & Slave kits (SILICON CHIP, October to December 2010) from Altronics and am now at the stage to load the sequences and WAV files to the SD card. I have a 1GD SD card (FAT format) to use and have downloaded the files from your website. However, I would like to confirm what files are required on the SD card. Is it a WAV file and LSN file or LSQ file or all three? (M. H., via email).

● If you put just a WAV file on the SD card, it will play the audio but the lights will remain off. If you put a WAV and LSQ file with matching names (except for the extension) then it will play the audio and control the lights simultaneously, using the commands from the LSQ file.

An LSN file is used if you want to control lights with no audio. In this case, it simply plays back the command sequence. So for normal use you want pairs of WAV and LSQ files.

Speedo corrector malfunction

I recently bought a Speedo Corrector kit to fit to a customer's customised Mazda MX5 which has a Ford gearbox and uses a Hall Effect speed sensor. I have bought over 10 of these kits in the past and have never had any problems with them.

I cannot get it to work. I have bench-tested the kit with my signal generator. I get a flashing LED but I don't seem to get any output signal. Could you please advise me? The LED flashes in the car as well. I also have a pulse counter and it is telling me the speedo sensor is working. (J. B., Manly, NSW).

● The fact you have a flashing LED does mean that the Speedo Corrector is probably working up to the output of IC1. That means the problem would lie with transistors Q5, Q6 and associated resistors and the capacitor.

Make sure that LK1 or LK2 are inserted and the link 5 is inserted (for AC out). Check that Q5 is a BC337 and Q6 a BC327. Otherwise check the resistor values and the soldering associated with Q5 and Q6.

Courtesy light delay circuit fault

I have had the Courtesy Light Delay circuit (SILICON CHIP, June 2004) installed in my car for the last two years and it was working. But now the courtesy light stays half lit after the delay period and not fully turned off.

Can you nominate which part of the kit has failed in order to fix it, rather than me getting a new kit? (H. S., via email).

● It is possibly an open circuit (or high resistance) 470Ω resistor (R1) that

Heatsinks & The HiFi Headphone Amplifier

I am assembling the Hifi Headphone Amplifier (SILICON CHIP, September & October 2011) and I have reached the stage where I am mounting the regulators and power transistors on the heatsinks. Is it safe to mount the heatsinks flush on the PCB where there are etched links on the board's top surface?

The reason for this quandary is that some time ago I constructed one of these amplifiers and it failed, thus destroying my headphones but not blowing the fuse. Nor was there any smell from the amplifier. Later, when reflecting on this outcome I did attribute some blame on the heatsinks shorting on the links, particularly when I didn't use a silicone washer under all of the regulators etc as I figured that there appeared to be an adequate coating of insulating material on the board's top surface.

Now I don't want a monumental failure like that again and this time I'm using the silicone washers between the heatsinks and the power semiconductors. So I'm asking for your advice of whether it would be wise to mount the semiconductors using the shoulder on the semiconductors leads, thus raising them off the board's surface by 1mm as a safety measure.

● It is not necessary to mount the heatsinks slightly proud of the PCB but it won't hurt to do so. Double-sided PCBs already have the links as part of the PCB pattern, ie, it is not necessary to install the links since they are already there in the copper pattern.

However, once you have assembled any PCB, it is always a good idea to carefully examine it to look for any potential shorts between adjacent components, heatsinks or whatever.

Multi-Receiver UHF Project Design

I am writing to you in the hope that your technical gurus can give me a hand to come up with a solution for a wireless transmission project which (at first glance) appears simple but has some limiting factors that I am finding hard to resolve. The overall system needs to have a range of at least 100 metres, one or more coded/matched receivers (max. 50) with a transmission rate less than the receiver delay, eg, transmission every two seconds and a delay within receiver to turn off if no "on" signals received in say a 15-second period.

I have produced and experimented with a prototype pair, with a PICAXE chip in each end. This allowed me to code the Rx/Tx pair and to provide different responses according to the code received – flashing six LEDs in various patterns and sequences. However, this surpasses the initial needs and makes the devices extremely costly. I need to get it pared down to basics and minimum requirements.

I have seen doorbell devices which seem to have similar functions but with drastically reduced real estate and components. Unfortunately, I do not understand electronics enough to recognise the components and understand their functionality.

I would be grateful for any design advice or recommended reading on this subject. On that last note, has anyone out there any advice or information about how to get from prototype stage to development. For example, is it best to manufacture "in house" until the concept is developed and then refine it and then outsource, or is it best to employ the boffins from the start and design the whole project to be outsourced from the word go?

Is Chinese manufacturing viable and how do you enter this domain? Overall the product must have high quality, great reliability, low cost, and be simple to configure. (K. K., via email).

● We developed a similar unit in the November 2007 Water Tank Level Meter where several transmitters could each send data to a receiver. Your application requires separate receivers but the principle is the same, with each transmitter sending a specific address code as an identifier. The receiver can separate out an individual transmitter based on the identifier code. The range was 100m.

A doorbell can be made rather simply but not so an application requiring transmitter identification encoding.

You will need a microcontroller in order to be able to send the coding and receive the encoding signal. PICAXE processors would be more expensive and you would need to use standard microcontrollers (eg, PICs) to reduce the cost.

As far as development, prototype and final production, those decisions need to be based on each particular design you are doing. There is no direct answer as to whether you should design on or off shore and manufacture on or off shore.

is allowing the 470µF capacitor (C1) to leak sufficient current to keep the Mosfet partially switched on. Either that or there is leakage on the PCB itself.

You should also check the 470µF and 47µF capacitors. Alternatively, water may have caused corrosion and leakage on the PCB.

DAB+/FM tuner has swapped channels

I am presently building the DAB+/FM Tuner (Silicon Chip, Oct-Dec 2010) from a kit provided by Jaycar. I have found that the solder tabs on the RCA socket provided for CON9 do not match the holes in the PCB. This is not a big issue but an investigation of the PCB and the component layout has caused me to query whether the Left and Right audio outputs, as marked on the PCB, may be reversed.

I am assuming that the AUDL and AUDR outputs from the Venice 7 module are indeed at pins 29 & 30 respectively, as shown in Fig.1 for the main board circuit diagram. Also, when looking at the PCB layout as shown in Fig. 3, pin 29 is RHS bottom and pin 30 RHS top of the 30-way header. Would you please confirm if this is correct?

If the above findings are correct, I can easily make the necessary changes to route the respective Left and Right audio outputs to the correct RCA sockets However, before doing this, I wonder if you would like to clarify the situation regarding the Venice 7 outputs and/or the PCB layout and markings? (G. G., via email).

● You are the first to raise a question about the left/right outputs of the Venice module and on the PCB.

Looking at the PCB overlay on page 71 of the November 2010 issue, pin 29 of the Venice module goes to pin 5 of IC4 via a 100nF capacitor. This agrees with the circuit on pages 26 & 27 of the October 2010 issue. So it does appear that the outputs of IC3 have been swapped. You could fix this by crossing over the 100Ω resistors from pins 1 & 7 of IC3. There should be no need to cut tracks etc.

The surprising thing is that no-one else has discovered it during listening tests. If you are listening to a symphony orchestra, for example, you always expect the lead violins to be on the left channel.

Ignition system for a Datsun Skyline

Could I use the ECU/coil tester version of the High-Energy Ignition (Silicon Chip, November & December 2013) while retaining my Pertronix Ignitor as a trigger in my old Datsun Skyline C210?

Would I have to put another resistor in line to drop the incoming voltage to 5V? Or just give it a go by connecting the lead that used to go to the coil from the Pertronix Ignitor straight to where the new High-Energy Ignition would receive a signal from the ECU? (B. K., via email).

● The coil output from the Pertronix Ignitor would need a 1kΩ 0.5W pull-up resistor to 5V (ie, connect a 1kΩ resistor between the High-Energy Ignition input and 5V) for the new ignition system to receive the signal. That's when it is assembled for the ECU style input. For a points input on the the High-

Energy Ignition, you can just connect to the Pertronix Ignitor directly since there is the 100Ω pullup resistor inside the High-Energy Ignition.

Cordless tool battery packs

Over the years you have published a number of Nicad battery charger projects, promoting them as a better solution for the nasty chargers that come with most power tools. I have always purchased middle-of-the-range power tools and so thought I would never have the problems you described.

How wrong I was. With a drill less than two years old, (a well-known German brand, though probably made in Asia these days), both battery packs appear to be totally fried. One just won't accept a charge any more, while the other holds the charge for about 10 minutes (standby time, not usage time!)

So what is your most recent or best recommended project for constructing a superior battery charger and are the Nicads in my fried battery packs recoverable? Or should they go to recycling and I start with fresh after-market packs? (B. R., via email).

● We published an NiMH Battery Charger in September 2007 that monitors cell temperature and switches off the charge when the cells rise in temperature at the end of charge. It includes top-up and float charge if required. Also in Circuit Notebook in February 2011, we featured a Nicad/NiMH Battery Charge Controller. This also senses thermal rise in the cells.

The life of the Nicad cells depends on usage and how they are charged. Usually they are not usable once they do not hold charge. NiMH cells tend to be better than their Nicad counterparts.

Wheelie bin reminder LEDs are anemic

I have just completed building the "Garbage & Recycling Reminder Kit" featured in the January 2013 issue. All functions work fine and the LEDs flash in accordance to the appropriate link settings, except that the blue LED is so dull I have to take the unit into a darkened room to check that it is in fact flashing.

The yellow and green LEDs flash brilliantly and the red is just mediocre. Could you please advise me what action I can take to remedy this situation? (R. C., Valley View, SA).

● Apart from checking that the soldering is good for these LEDs and associated components, check that LED1 and LED4 are orientated correctly. In addition, check that the 100µF capacitors and diodes D1 & D4 for the red and blue LEDs are orientated correctly. Also check that the 1kΩ resistors at the cathodes (K) of LED1 and LED4 are the correct value.

If the red LED remains mediocre in brightness, check that it does have sufficient brightness in comparison to the green and yellow LEDs when separately driven at about 3mA (1kΩ in series with the LED and a 5V supply).

Fan cooling for hot battery charger

I have a 3-stage battery charger which will charge Lead-acid, SLA and Calcium batteries. It's a 12V 8A model and has given heaps of trouble-free service. Since I bought this charger, it has always run hot; quite hot actually. The case is aluminium and is used as a heatsink but it lacks forced air cooling.

I decided to fit a small cooling fan and I drilled a pattern of holes in the top of the case and another pattern in the rear of the case to allow for air-flow. Now if I connect the fan to the 12V output, will the various voltage modulation patterns from the charger damage or prevent the fan from running and, will the fan cause any issues with the monitored waveform/voltage from the battery back to the microprocessor?

I cannot locate a circuit diagram and removing the PCB from the case would entail a fair amount of work as all connecting cables etc are soldered to the board and not socketed. The charger is powered using a switch-mode power supply and I am reluctant to mess around around that section of the board, for obvious reasons.

The charger was expensive and I am trying to avoid heat damage to the board and components and the expense of replacing the charger. Any advice would be greatly appreciated. (D. S., Maryborough, Qld).

● The charger should run the fan in all its modes and the fan should have negligible effect on the charger functions.

Query on LED down-lights

The popularity of LED down-lights is evident by the many forums discussing the ongoing flickering problem. They fit them only to discover that they flicker when fitted to halogen drivers.

I have started to experiment and had little success in designing an add-on circuit for existing electronic drivers. These cheap drivers mainly consist of a self-oscillating circuit derived from the mains and tend to perform erratically when not driving the correct load. There are dedicated LED DC driv-

Why Don't GPS Receivers Have A Time Function?

One of the modern mysteries to me is the following. Assuming ordinary GPS receivers (OEM in cars, hand-held, marine, etc) are parsing a GPS receiver's NMEA 0183 data stream virtually continuously, why do none offer a local, or even a UTC, time feature?

I guesstimate that fewer than 10 lines of code would do the trick and material costs should be nil for the average touch-screen device. What am I missing or have failed to understand in all this?

Keep up the great work including clocks and related uses of accurate GPS-derived time/frequency. (L. W., Chifley, NSW).

● Good question; why not? As you say, it would only take a few lines of code. The answer will vary depending on the type of GPS that you are talking about. For example, the Tom Tom series will display the local time and has the facility to set that time along with a tick box labelled "Automatically synchronise time", which will lock the time to the GPS transmitted UTC.

Probably the real reason why some do not is because the designers are concentrating on making the driving/navigating/set-up experience as simple as possible. A newspaper writer once referred to her GPS as "my sexy and intelligent best friend" – she would not be interested in getting the time accurate to the millisecond.

Speedo Corrector Makes Odometer Incorrect

I have built and am using the Speedo Corrector MkII from the December 2006 issue. I notice that the odometer is now incorrect. What is the easiest way to solve this problem? (M. S., Keilor Downs, Vic).

● The speedometer and odometer in a car use the same speed/distance pulse signal. The speedo corrector modifies the signal applied to the speedometer so any changes made to the speedometer reading by adjusting the speedo corrector multiplier settings will also affect the odometer.

The only solution is to try and locate the two different sections of your speedo and odometer. Then connect the unmodified speed signal at the input to the speedo corrector to the odometer section and the output of the speedo corrector just to the speedometer itself.

ers available. How effective they are I'm not sure but I can see drawbacks to these drivers.

As the general population would like to be able to fit either LED or halogen when the mood suits, have you guys published anything along these lines? (H. G., via email).

● Unfortunately, there is no way to run MR16 LED replacement lamps from electronic transformers. If fitting LED replacement lamps, you will need to change the transformer to a standard (linear) type. You could then swap the lamp between halogen and LED if you wished.

However, it is possible to get significantly higher efficiency by running several LED lamps off one 50W transformer and if you did that, it would no longer be possible to use halogen lamps in those sockets as they would overload the transformer.

Transformer for CLASSiC-D amplifier

After purchasing your November & December 2012 issues I am pretty keen to build the Classic-D Amplifier module kit. I'm a little lost as to what would be a good transformer for this. Can you recommend one to purchase? (R. P., via email).

● This amplifier is quite flexible as to the transformer you can use. It can be set to operate with supply voltages ranging from ±25V up to ±55V.

Our recommendation, if you want high power output, is to use a 300VA toroidal transformer with secondary voltages of 35VAC x 2 or 40VAC x 2. In fact, this was suggested in the power supply parts list on page 71 of the December 2012 issue.

Have a look at the 35V toroid that's available from Altronics: Cat. M-5535.

Spa pump controller

I wish to heat my spa tub using solar energy. Do you have a pump controller diagram or article for this purpose? (I. M., via email).

● The closest circuit we have to a solar spa heater controller is the Spa Heater Control (for gas heating) in the Circuit Notebook section of the January 2008 issue. Perhaps this could be used but with the solenoid valve that controls the gas on/off instead controlling hot water flow from a solar hot water tank to exchange heat to the spa water.

Query on FND500 7-segment displays

I have just started building the kit for the Digital Spirit Level (Silicon Chip, August 2011) and have come to the step where it is required to fit the FND500 displays. However, the spacing on the board for the displays appears to be wrong. You have 20 holes each side spaced at 0.1 inch. It should be five at 0.1 then a 0.2 gap, then five at 0.1, then a 0.2 gap then five at 0.1, then a 0.2 gap then five at 0.1. My displays are to specification in the mid band of the measurements at 15mm.

I have already paid £30 to have the SMT chip fitted as I did not feel I was capable and have since fitted all the resistors, transistors, electrolytics and other parts. Please advise on how to remedy this situation. (P. R., via email).

● It turns out that the FND500 displays that are sold by Jaycar and Altronics and used in our prototypes are not the genuine article. They are pin-for-pin compatible with the original FND500 specification which is a very old device originally sourced by Fairchild (we think) but their body is narrower.

So the "proper" FND500s don't fit, as you have found, and what we have regarded for years as FND500s are actually not the original spec device.

These devices appear to be identical to Liteon LTS547AP although we cannot be completely sure.

The odd thing is that these narrower

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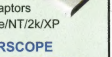

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Ask SILICON CHIP
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displays have been sold as FND500s by Jaycar and other companies for quite few years so no-one has questioned this situation. The simple fix is to buy the displays from Jaycar or Altronics but we realise that might rankle a bit since you cannot use the FND500s you have on hand in this project.

Red displays for frequency meter

I am very interested in building the new 2.5GHz 12-Digit Frequency Counter in your December 2012 & January 2013 issues. Can you please tell me what modifications would be needed to change the three 7FB5641AB quad 7-segment blue displays to 7FR5641AS quad 7-segment red displays from Futurlec? (P. O., via email).

● Erk! Red! You would prefer to use boring old red rather than the scintillating blue LED displays we used?

OK, you can use the 7FR5641AS quad 7-segment red displays but as they are a little more efficient than the blue displays (at least in terms of visible brightness), you may wish to increase the value of the segment current-limiting resistors from 47Ω to 68Ω. This will reduce the display current and will probably still give you a sufficiently bright display.

VHF aircraft receiver input confusion

I have just finished building the VHF Aircraft Receiver from page 55 of the Circuit Notebook section in the December 2008 issue. In the first paragraph of the item, it states that the antenna is coupled via a 10nF capacitor to the base of transistor Q1. However, the circuit diagram has the antenna connected to the emitter of Q1 via a 10nF capacitor.

I have checked the errata in later editions and haven't seen any corrections on this. Have there been notes or adjustments in SILICON CHIP about this receiver that I have missed? (K. M., via email).

● Since the base of Q1 is effectively grounded by the 10nF capacitor, the input must be to the emitter, as indicated on the circuit. Grounded base amplifiers are common for RF applications.

Smaller inductor for iPod charger

I have a question regarding the circuit used in the article entitled "Build a Charger For Your iPod or MP3 Player" from February 2006.

I understand this article was written a while ago but I was wondering if there was an alternative to the inductor used in this project. I was hoping to use a smaller inductor to keep the project a bit smaller overall. (T. S., via email).

● If you want the full charging current from the February 2006 charger, then the inductor needs to be 220µH and with the core size specified. A smaller inductor will not reduce the charger size much overall with the PC board, sockets, capacitors and other components also taking up space. SC

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Notes & Errata

DAB+/FM Tuner (SILICON CHIP, October to December 2010): The left and right audio channel inputs are swapped over on the PCB. This can most easily be corrected by crossing over the 100Ω resistors from from pins 1 & 7 of IC3. It is not necessary to cut or alter tracks on the PCB.

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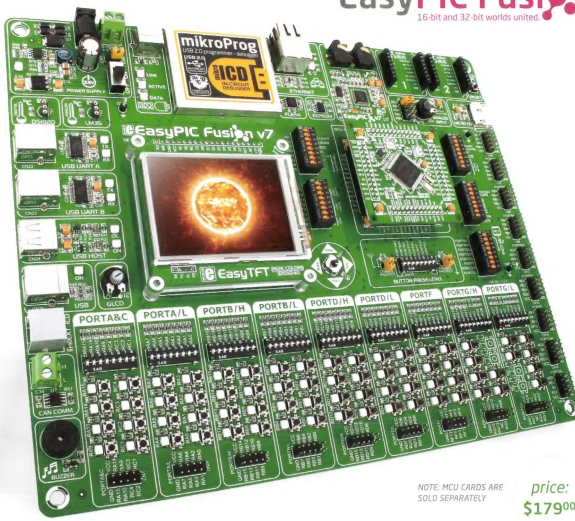

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